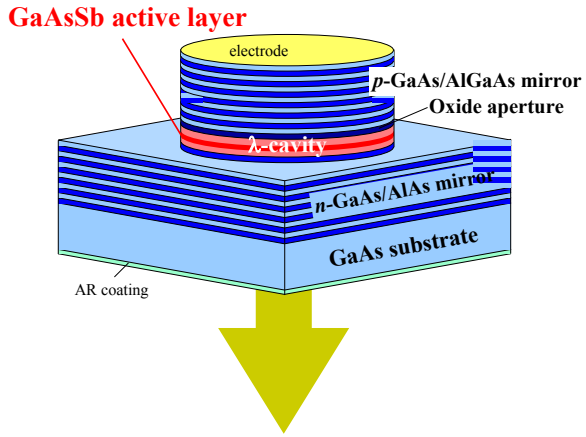
GaAsSb Long-Wavelength VCSEL

Low power consumption optical interconnection

Optical Interconnection NEC Laboratory

Description of the Achievements

A high-performance, cost-effective 1.3-μm vertical-cavity surface-emitting laser (VCSEL) — suitable for high-speed and high-capacity optical-communication — has been developed.



Significance of the Achievements

Optical interconnection, which is used in distributed and parallel computing, is in strong demand to meet the need for systems with high speed and high capacity. Although, conventional VCSELs are considered key-devices for optical interconnection, it is necessary to develop an optical device with lower power consumption and higher-capacity transmission. In order to satisfy this requirement, we have developed a 1.3-μm (long-wavelength) VCSEL. The main advantages of this VCSEL are as follows.

- Broadband and high-capacity optical interconnection due to the operation at a 1.3-μm wavelength, at which optical-fiber dispersion is minimum.
- Low-cost production due to mass productivity; namely, the whole device structure can be grown in a single-step growth on a GaAs substrate.
- Eye-safety regulations can be replaced because a long wavelength is used.
- Lower power consumption: advantageous for making array devices.

Technical Developments

One of the major problems in producing a 1.3-μm VCSEL is the lack of the adequate combination of a distributed Bragg reflector (DBR) mirror with high-contrast refractive indices and an active layer material which emits light at 1.3 μm. The following technical developments overcome this problem.

- Strained GaAsSb on a GaAs substrate was used as a 1.3-μm active layer.
- GaAs/AlGaAs was utilized for the DBR mirror to provide low optical loss and low electrical resistance.
- Strained GaAsSb combined with the GaAs/AlGaAs DBR mirror enables single-step growth of VCSEL structure on a GaAs substrate.

Demonstration

In the exhibition, we will explain the growth and process technology as well as the detailed structure of the developed 1.3-μm VCSEL. We will also provide details of its performance and exhibit an actual device at our stand.

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Long-Wavelength Laser Diode on InGaAs Substrates

Low driving voltage VCSELs for optical interconnection

Optical Interconnection Fujitsu Laboratory

Description of the Achievements

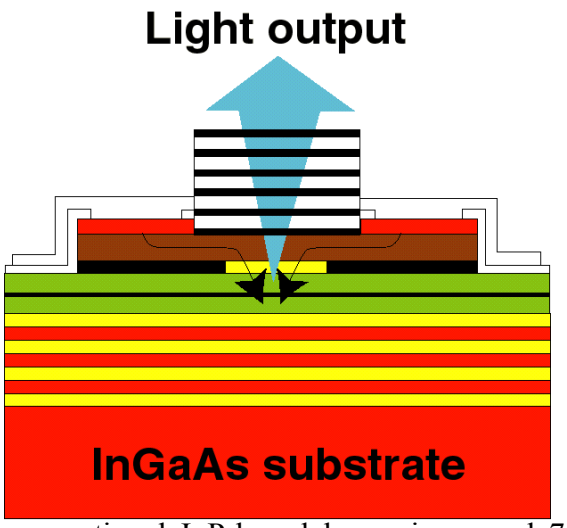
Novel semiconductor substrates enabled 1.3 μ m lasers with excellent temperature characteristics, owing to high performance active layers. We also realized high reflectivity DBR mirrors on the InGaAs substrates, which are essential for 1.3 μ m VCSELs.

Significance of the Achievements

- High performance 1.3 μ m active layers and high reflectivity semiconductor DBR mirrors are essential for 1.3 μ m VCSELs . We obtain them with novel material technology.
- Practical and high performance 1.3 μ m VCSELs, which should be impossible wjth conventional technique, are feasible.
- There is an intensive need of low driving voltage 1.3 μ m VCSELs for future optical interconnection.
- 1.3 μ m VCSELs with low built-in potential are suitable for low consumption power optical interconnection.

Technical Developments

- We usually use InP or GaAs substrates for fabrication of semiconductor lasers. In this work, we propose the use of novel substrates, that is, InGaAs ternary substrates.
- We can fabricate large optical gain 1.3 μ m strained quantum wells on InGaAs ternary substrates, whose potential depth is much deeper than those on InP substrates.
- High reflectivity DBR mirrors are also feasible on the InGaAs substrates because we can choose the material system with large refractive index contrast, that is, InGaAs and InAlAs.
- We fabricated 1.3 μ m strained quantum well stripe lasers on the InGaAs substrates. A low threshold of 148 A/cm^2 and a high characteristic temperature over 100 K (T_0; the higher the T_0, the smaller the temperature dependence of threshold. The typical T_0 of conventional InP-based lasers is around 70 K.) are simultaneously realized in 1.3 μ m lasers.
- We also fabricated 25-pair InGaAs/InAlAs DBR mirrors on the InGaAs substrates. Their reflectivity is over 99.5% at 1.3 μ m, which is enough for lasing of VCSELs.
- Moreover, we developed the technique of forming native oxide of InAlAs for current confinement structure.



Demonstration

We will exhibit the semiconductor lasers fabricated onto the InGaAs ternary substrates. A detailed explanation panel, which includes the visualized merit of using InGaAs substrates and laser characteristics, will be also exhibited.

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Passive-Aligned VCSEL Array Module

Alignment Free Surface Emitting LD Module

Optical Interconnection Furukawa Laboratory

Description of the Achievements

We have developed a 10-channel p-substrate 980nm vertical cavity surface emitting laser (VCSEL) array with low power consumption and more than 3.125 Gb/s/ch modulation and passive-aligned module with direct coupling of the VCSEL array and tape fiber.

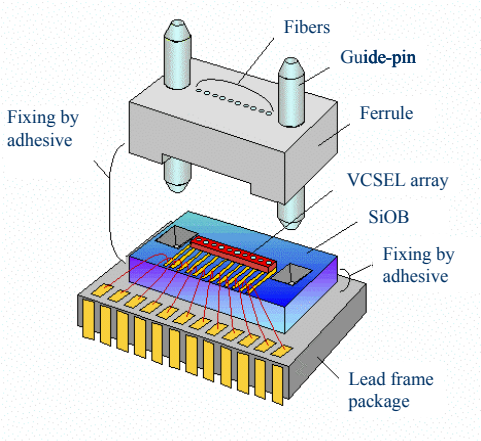

Fig.1 Design Concept for passive-alignment VCSEL array module.

Significance of the Achievements

- Costs of optical modules are reduced by developing a passive-aligned module with direct coupling of VCSEL and fiber and with plastic package.
- Module with low power consumption operation is realized by developing a VCSEL array with low threshold and low driving voltage.
- Optical interconnection with high-speed data transmission is possible by realizing p-substrate 980nm VCSEL array which can be operated by a high speed LD driver with bipolar transistor circuits.

Technical Developments

- We have developed a p-substrate 980nm VCSEL array with oxide current confinement in order to use a high-speed LD array driver with npn bipolar transistor circuits, which has anode common. 10-channel VCSEL array with low threshold, low driving voltage and more than 3.125Gb/s/ch modulation has been realized
- Passive-aligned modules have been realized. Their technical developments are as follows. A plastic ferrule, which has holes of guide-pins and holes of fibers as same as MT connector, and a silicon optical bench (SiOB), on which VCSEL array is bonded, are used. Guide-pins or bolls that connect holes of ferrule with grooves on the SiOB to align fibers and VCSELs are employed. The ferrule and the SiOB are fixed by transparent resin.
- 10-channel passive-aligned VCSEL array module with 2.5Gb/s/ch operation has been realized

Demonstration

- A structure, and characteristics of 10-channel p-substrate 980nn oxide VCSEL are shown in PC. Design concept for passive-aligned VCSEL array module with direct coupling of VCSEL array and optical tape fiber is explained and its structure, sequence of the assembly, static characteristics and transmission characteristics are shown in PC.
- Prototype 10-channel VCSEL array modules are exhibited

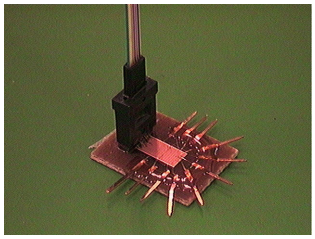

Fig.2 Prototype 10-channel VCSEL array module

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GaInNAs Long-Wavelength Laser Diode

Optical interconnection for a large-throughput data bus system

Optical Interconnection Hitachi Laboratory

Description of the Achievements

We have developed a novel semiconductor material, GaInNAs, which is applicable to 1.3-μm-range laser diodes. It is possible to make devices with superior performance than current ones because of the uncommon physical properties of this material.

GaInNAs lasers have the following characteristics.

a. High optical gain suitable for high-speed operation
b. A deep quantum well, especially in the conduction band, suitable for high-temperature operation
c. Lasing wavelength in the 1.3-μm range
d. Applicability to vertical cavity surface emitting lasers (VCSELs)
e. Low price and mass producability due to the use of a low-price GaAs wafer with a large diameter

GaInNAs laser diodes are therefore promising as a light source used in the next generation of optical interconnections.

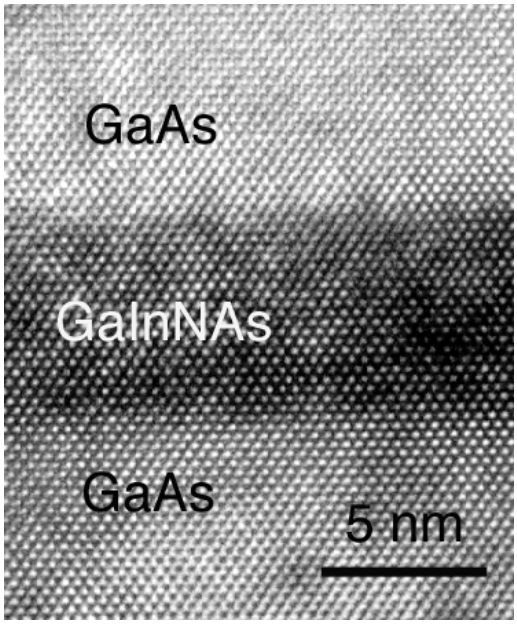

Fig. 1 Lattice image of GaInNAs/GaAs quantum well observed by transmission electron microscope (TEM)

Significance of the Achievements

Optical transmitters based on this material for next-generation optical interconnections will provide excellent performances at low cost. Transmission speed in a current top-class optical network switch is approximately 1 Gbps. If we use GaInNAs-based transmitters, it can be increased to 10 Gbps in the near future.

Technical Developments

1. Crystal growth technique for GaInNAs
   We have developed molecular beam epitaxy technique in which nitrogen radicals are used as nitrogen source. By optimizing growth conditions etc., GaInNAs with crystallinity as excellent as a conventional material of GaInAs was obtained.
2. Feasibility examination in a practical laser diode
   Material parameters of GaInNAs were investigated. Feasibility of the material was checked in a practical laser diode. Excellent properties on operation speed, hi-temperature performance, lasing wavelength stability、reliability etc. were demonstrated.

Demonstration

GaInNAs laser diodes under a ultra-high-speed operation will be demonstrated.

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Fiber-Bragg-Grating Laser Module

WDM optical local area network

Optical Interconnection Sumiden Laboratory

Description of the Achievements

1)Fiber-Bragg-grating laser diodes (FGL) with a fiber-Bragg-grating (FBG) functioning as an external-cavity mirror have been developed for wavelength division multiplexing (WDM) systems.

Transmission experiment (2.5Gbps, direct modulation, 300km) of super-dense WDM with the wavelength spacing of 12.5GHz (0.1nm) - 25GHz (0.2nm) was successfully demonstrated.

2)FGLs which have one order superior wavelength stability to conventional DFB lasers were developed. The FGL modules operating without temperature control were realized for the first time. To reduce the module cost and size, a coaxial package was adopted.

Significance of the Achievements

1) Increase of wavelength number in WDM systems; and consequently expanding transmission capacity is possible owing to the excellent emission-wavelength stability against temperature and driving current fluctuation.

2) The FGL is applied to dense WDM systems without temperature control of a semiconductor chip.

Lower cost, reduced power consumption, and smaller size WDM systems can be realized by the uncooled FGL modules .

Technical Developments

An FBG, acting as a wavelength selective external cavity mirror, enables the FGL to operate in a single longitudinal mode (Fig. 1).

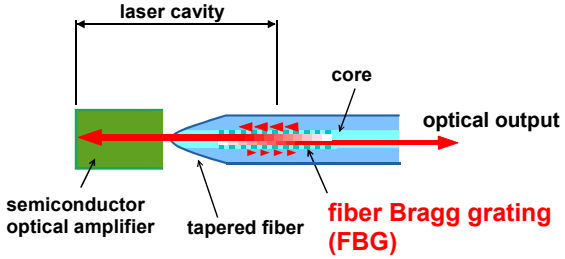

Figure 1 Principle of FGL operation

The emission wavelength of FGL is determined by the diffraction wavelength of FBG. Due to the small temperature dependence of diffraction wavelength of FBG (10pm/℃) , the FGL emission wavelength is stable against temperature change (Fig. 2).

The variation of the emission wavelength caused by the driving current shift during the device life time was suppressed less than 1/10 of conventional DFB laser modules.

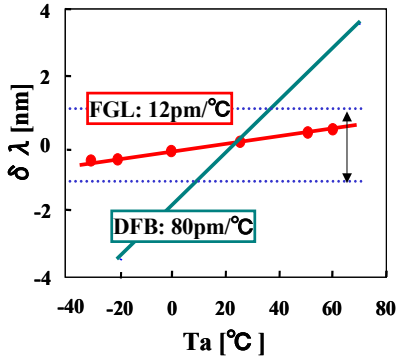

Figure 2 Comparison of wavelength stability of FGL and DFB lasers. Ta indicates ambient temperature. (Temperature in each module was not controlled.)

Demonstration

FGL modules for super-dense WDM systems (Fig. 3a), and uncooled coaxial type FGL modules for WDM systems (Fig. 3b) are exhibited. Technical data are also shown in our booth.

Figure 3a

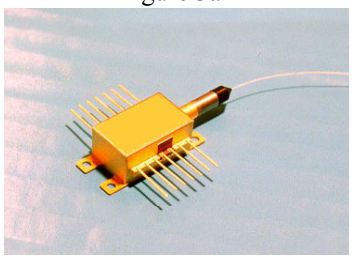

Figure 3b

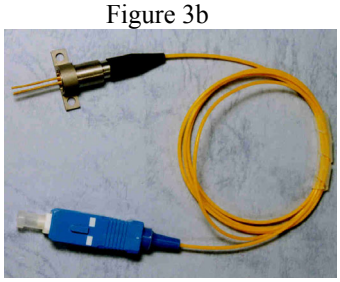

Figure 3a FGL module for super-dense WDM systems
Figure 3b Uncooled coaxial FGL modules

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Micro-Hole Array

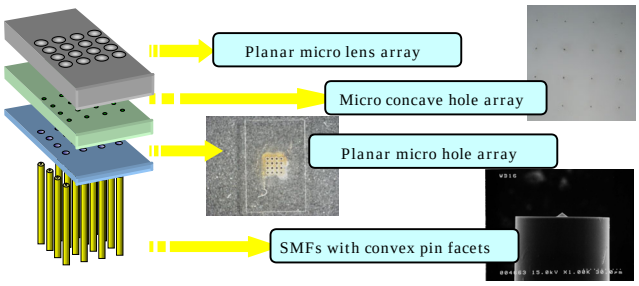
Space division multiplexing optical interconnection

Optical interconnection NSG Laboratory

Description of the Achievements

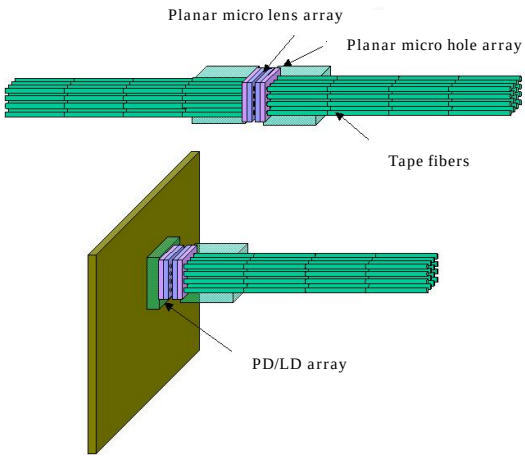
We developed a 4x4 arrayed the 0.25mm pitch 16 channel dense space division multiplexing (SDM) optical interconnection using a planar micro lens array (PML), micro hole arrays and optical fibers with the convex-concave self-alignment mechanism. We improved optical characteristics of coupling efficiency variations and near channel crosstalk.

And we realized that the interconnection was a good solution for on-board and board-board optical interconnections.



Significance of the Achievements

We obtained the dense two-dimensional SDM optical interconnection, which was applied the self-aligned common optical platform. It was applicable from coupling use to collimating use.

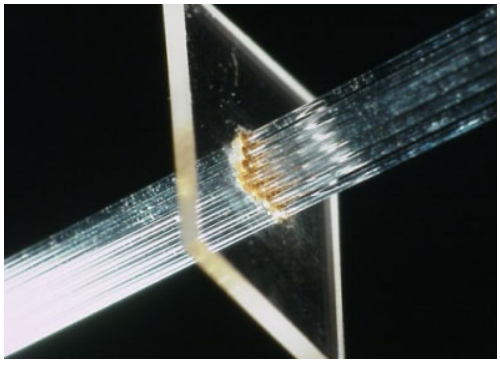


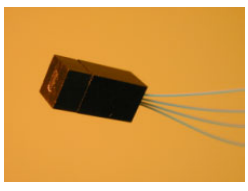
Technical Developments

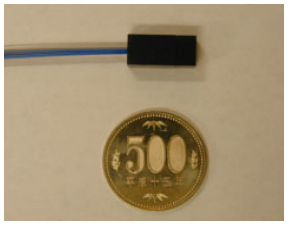
The dense two-dimensional SDM optical interconnections were achieved by using the precise planar micro hole arrays, in comparison with usual one-dimensional parallel optical interconnections which were applied V-groove optical fiber arrays.

Demonstration

We demonstrate the 0.25mm pitch 4x4 (16ch) arrayed dense SDM optical interconnection prototype which was applied the planar micro lens array, the planar micro hole array, the micro concave hole array and the optical fibers whose facets were shaped convex pins on core regions. The prototype was packaged by using the self-aligned technique. We also indicate the elements, which were used in the prototype.







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Skew-Suppressed Fiber Ribbon

New multi-mode fiber ribbon for optical parallel interconnection

Optical Interconnection Fujikura Laboratory

Description of the Achievements

For a fiber ribbon used in optical parallel interconnection, skew (delay time difference among fibers in a ribbon) is one of the important transmission characteristics dominating the system performance and has been required to decrease. We have developed a new intermittently fixed fiber ribbon with excellent skew property and other transmission characteristics especially in bending and twisting resistance.

We have realized a multimode fiber ribbon with a skew of 0.43 ps/m. The achieved skew is obviously much lower than that of conventional low skew fiber ribbons (0.8 ～2.0ps/m).

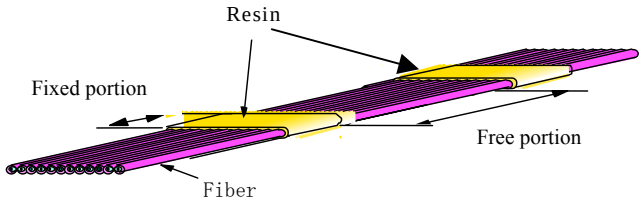

Fig.1 Schematic diagram of new fiber ribbon

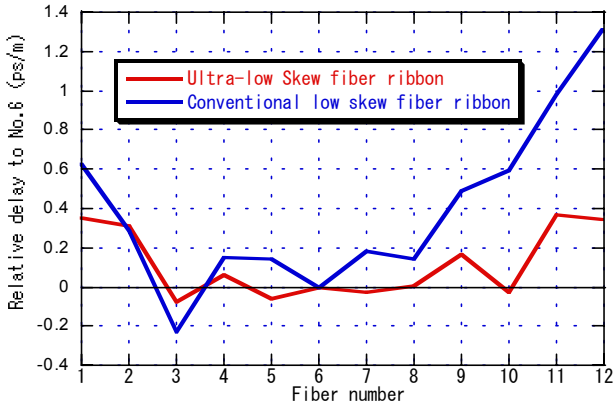

Fig.2 Skews for ultra-low skew and conventional skew fiber ribbons

Significance of the Achievements

The optical parallel interconnection system only has been used for short distance transmission , such as between a room and next room. From now, we are able to use it for long distance transmission, such as between buildings and buildings, because of the skew of new transmission line is much lower than that of conventional one. The skew of conventional fiber ribbon is about 2~4 times larger than that of ultra-low skew fiber ribbon.

Technical Developments

In contrast with conventional fiber ribbons, the fibers in the new fiber ribbon are not fixed each other at everywhere along the fiber, but fixed intermittently as shown in Fig.1. This structure is effective for skew reduction because it reduces the strain induced in the fiberglass during the ribbonization process. Sections where the fibers are not glued each other have large flexibility of transformation such like bending or twisting and the fiber dose not experience a tensile or compressive stress when the fiber ribbon transforms. The new intermittently fixed fiber ribbon realizes the excellent skew characteristics owing to the transformation flexibility.

Demonstration

In order to demonstrate the outstanding feature of the new intermittently fixed fiber ribbon: flexibility to external forces, we exhibit samples of a new intermittently fixed fiber ribbon and a conventional one for comparison. Touch them and you can really feel the difference.

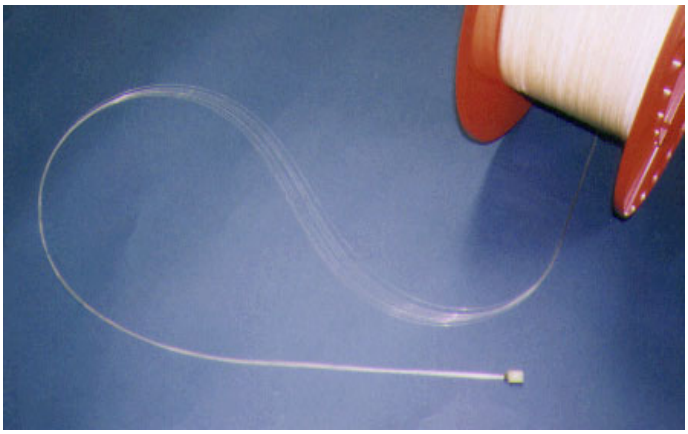

Fig.3 Ultra-low skew fiber ribbon

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Inter-Chip Optical Interconnection

Optical Bass

Optical Interconnection Oki Laboratory

Description of the Achievements

We experimentally demonstrated technical breakthroughs of optical interconnections for inter-computer, intra-computer and chip-to-chip levels crucial to the seamless optical interconnection hierarchy both in micro and macro topologies.

Significance of the Achievements

By using high-speed and large bandwidth optical interconnections, one can ignore signals skews. This enables us to design high-performance and yet compact computer architectures in which computing functions are distributed among many processing boards.

Inter-chip optical interconnection is expected to evolve the computing capability into the next level by solving pin I/O bottleneck of LSIs and fully exploit the potential of CPUs.

Future computer architecture design should not be limited in a singe-chip CPU by the realization of the ultra-high-speed optical bus lines in a board level.

Above technological breakthroughs significantly enhance the capability of conventional PCs and dramatically increases the computation power of PC clusters.

Technical Developments

Ultra-compact data communication module is demonstrated by employing narrow-pitch parallel optical fiber receptacles.

Monolithic integration of light sources on Si LSIs and free-space optical interconnection that is capable of transmitting thousands of optical signals between LSI chips are experimentally demonstrated.

Demonstrations

Research achievements are graphically explained and summarized in a panel.

Data transmission between PC and an external storage device is demonstrated.

Video presentation explaining how the inter-board optical interconnection works.

Photonic circuit for free-space optical interconnection is displayed.

Optical module assembly to be used for inter-board data communications.

Reprints of previously published papers.

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Parallel Power Flow Analyzer

Parallel Processing Application in Power Systems

Parallel Application MRI Laboratory

Description of the Achievements

A parallel power flow analyzer has been developed for the increasing needs in on-line analysis and control of power systems under the circumstances of the deregulation in power market.

Significance of the Achievements

The algorithm utilized in this analyzer is considered to be more efficient in parallel processing comparing with the conventional algorithm for power flow calculation that was developed for single processor. It is expected to be able to obtain higher performance on general-purpose parallel computer. This algorithm had been tested on distributed-memory type parallel computer using public domain MPI interface package, and achieved a speed-up of about 11 times (32 PEs) for a 8436-bus power system model (Western system of US).

In the near future, more and more business entities will join in the power transactions. Under this circumstance, the central dispatching needs a high-speed system analysis tool for evaluating the states of large-scale system fast, in order to operate the power system optimally and impartially, while not causing degrading in power supply reliability. As the central dispatching system needs high reliability itself, it is considered that a satisfactory general-purpose parallel computer will be chosen for the introduction of parallel processing. Therefore, the developing of such a parallel calculation algorithm as the method improving proposed in this research is considered to be very useful in this case.

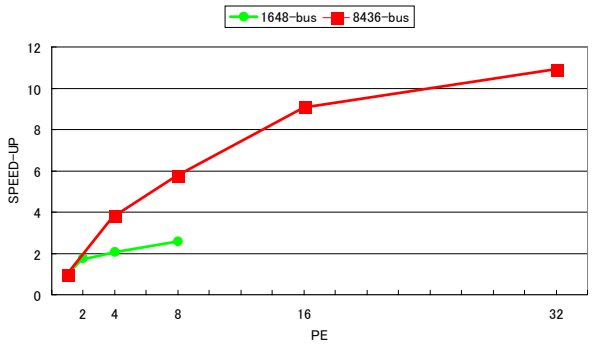

Fig. 1 Improvement of calculating speed by number of CPUs

Technical Developments

Power flow calculation solves a boundary condition problem of 2n nonlinear equations (n is the number of buses of the system). The parallelization of the conventional power flow calculation algorithm, Newton-Raphson method, is not suitable for the application on general-purpose parallel computer due to the needs of high level processor allocation and task scheduling techniques. In this research, an algorithm, which is efficient in both share-memory and distributed-memory type parallel computer and can be used for constructing high performance parallel power flow calculation software in general-purpose parallel computer, is developed using the Bi-CGSTAB algorithm based on the Krylov subspace method.

Furthermore, as an extended application, a new algorithm for optimal power flow problems is proposed based on the same theory. Optimal power flow solves a nonlinear optimization problem for a given object function with respect to the boundary conditions of power flow (equality constraints) and a set of system inequality constraints. This algorithm is expected to achieve a better parallel computing efficiency, by transferring an optimization problem with inequality constraints into the one with equality constraints.

Demonstration

The demonstration will show the prototype application of the proposed power flow and optimal power flow algorithms on share-memory type SUN Enterprise450 (4 PEs).

In the parallel power flow demonstration, an IEEE benchmark 118-bus power system model and a 1648-bus power system model (equivalent to the scale of simulation system in Japanese utility) are provided for parallel computing and performance evaluation.

In the parallel optimal power flow demonstration, a 30-bus and a 118-bus power system model are provided for parallel computing and performance evaluation of a problem of transmission losses minimization using terminal voltage and reactive power output as controls.

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Protein Structure Prediction

Parallel Computing of Physical and Statistical Simulation

Parallel Application Mitsubishi Laboratory

Description of the Achievements

Protein structure prediction problem asks how an amino acid sequence, which is regarded as a string of 20 sorts of characters, folds into a protein 3D structure. For instance, a relatively small protein chain of 100 amino acids rotates at least 200 dihedral angle parameters, in order to reach the optimal combination of the parameters in which the protein chain obtains a stable structure. This research employed statistical information extracted from the existing protein 3D structure database for the stability evaluation, realized a combined use of the physical constraints and the statistical information, and provided a system for the protein structure prediction problem.

Significance of the Achievements

Recent rapid advance of genome informatics and DNA sequencing equipment accumulates amino acid sequence data more rapidly than 3D structure data. This situation requires quicker supply of the 3D structures of the unknown amino acid sequences by the computational structure prediction. The achievements correspond to such requirement.

This research also proposed the way to install the statistical information obtained from the practical field into the simulation rules. The achievements enables, for instance, the micro simulation of the cars, in which the behavior rule of the car is defined, consider the statistics of the real traffics.

Technical Developments

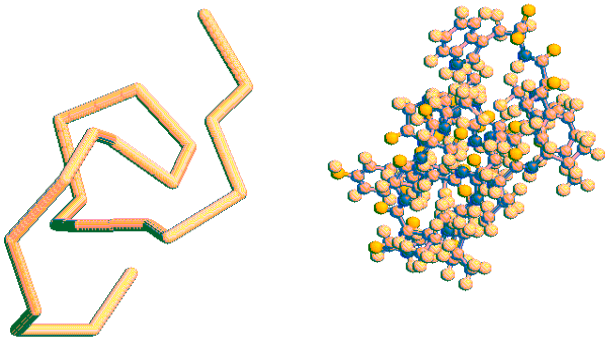
The statistical information is extracted from the protein structure database PDB. The extraction includes data-cleaning procedure using the protein representative chain database PDB-REPRDB, uniform fragmentation of the chains, and the parameter estimation of the specific statistical model. The mixture model of the several hundreds of diagonal covariance normal distributions is employed to describe the distribution of the structural characteristics of the fragmented protein chains. Combined use of this statistical model and the physical constraints refines the structure prediction.

The stable point of the protein chain is detected by the local search, which is one of the practical optimization methods. The orthogonal design of experiments with factorial analysis is employed to determine the reasonable direction of the local search. This realizes the efficient search of the optimal set of the enormous number of parameters.

The procedures of the model parameter estimation and the local search are tailored to parallel processing and are executed on PC cluster, distributed processing environment.

Demonstration

An amino acid sequence and two ways of the 3D structure representation are exhibited: each atom is displayed as a ball and each atomic bond is displayed as a stick (e.g. figure of the right-hand side) and the backbone is displayed (e.g. figure of the left-hand side).



The representations also illustrate how the simulated annealing, a conventional structure prediction method, and the local search using the orthogonal design of experiments fold the protein chain. These 6 sorts of representation are alternatively or simultaneously displayed according to the time-series of the folding, or rotating by themselves.

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Composite Simulation Tool

A common software structure for heterogeneous computing

Parallel Application Hitachi Laboratory

Description of the Achievements

Current technology in parallel and distributed systems allows users to exploit a variety of resources across networks. However, techniques that provide seamless computing at the application level are often insufficient for computational scientists to simulate complicated real-world scenarios. In this study, we have developed a new middleware system that allows multiple scientific simulations to be efficiently combined into a single program to perform high-fidelity simulations. The system provides high-level transparency in the form of agents that automatically transfer and transform physical values between interdisciplinary simulations.

Significance of the Achievements

Collaborative research between industrial, university and national laboratories is becoming increasingly indispensable in nano-technology areas such as bio-computing and the design of future semiconductor devices. A solution based on middleware has significant advantages for customizing interdisciplinary simulations that require the integration of simulation programs developed by advanced researchers and independent software vendors. It provides an ability to construct the best combination of a variety of scientific simulations on demand. The system can also improve physical accuracy and solve multi-scale simulations in which analytical regions extend from atomic level to macroscopic scale. To minimize impact on user programs, the middleware system provides a small number of library calls for combining different kinds of scientific simulations. The result is that it takes less than 1/5 to 1/10 the number of programming steps as would conventional development.

Technical Developments

To mask the complexity in combining discrete points from different types of simulations such as the finite difference method (FDM), finite element method (FEM) or particle method, the agents provide a variety of techniques for transferring and transforming physical values associated with these points. Features of the middleware system include:

(1) Fast searching for discrete points according to a correlative specification such as nearest points, first nearest neighbors and in-sphere.

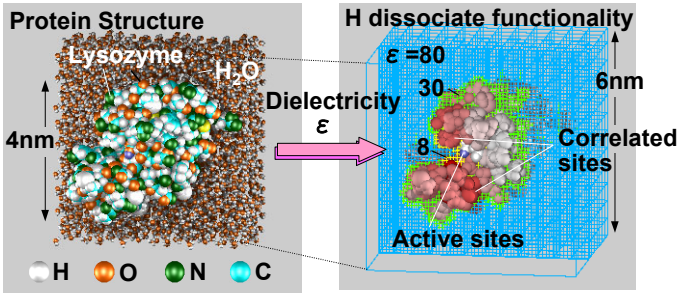
(2) A variety of techniques for semantically transforming the physical values associated with the correlated discrete points.

(3) Automatic determination of processes to which the physical values must be transferred without explicit task identifiers using standard message passing libraries such as MPI (Message Passing Interface) and PVM (Parallel Virtual Machine).

Demonstration

The middleware system has been applied to five composite scientific simulations. The simulations related to nano-technology are visualized in two animations: (A) a correlative analysis between protein structure and functionality, and (B) an ultra-small device simulation designing for high speed and high reliability.

In (A), Molecular dynamics (MD) simulation is combined with continuum electro-static simulation based on Poisson-Boltzmann (PB) equation. In MD using an independent software package, dielectric constant and electric charge associated with molecular in hydrate protein structure are transferred to PB by the agents. The electro-static energy of Hydrogen dissociation is calculated by using the physical values transformed to mesh points in PB. It is shown that dissociate coefficient of Hydrogen at active sites for protein functionality can be analyzed accurately in the state of the art. The composite simulation can be employed to identify significant sites that have strong correlation with the active sites to dissociate Hydrogen.



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Trademark Detector

Parallel and distributed processing For multi-media database

Parallel Application Sanyo Laboratory

Description of the Achievements

A method for fast data retrieval from a large-scale database, "Content Based Image Retrieval" is developed. It is based on a parallel technique for recognizing objects qualitatively by using their shape features. This technology plays a significant role for many applications in a wide area such as image data mining, video surveillance and so on. It can detect whether target objects for interest are included in input image frames or not, and where they are located in the detected image frames. The method is implemented on a parallel computer (PC cluster) for experiment to detect image frames which include target trademarks and their locations from movies.

Significance of the Achievements

By using our system, it can be investigated how many times sponsor company's trademarks were on the air on TV programs. For example, a new estimation system can be realized to evaluate the advertising effects. Since this method recognizes an object by using its edge information, it is applicable to monochrome input images in the field of security and industrial applications.

Technical Developments

Our method first extracts local shape features of objects by detecting edges in image sequences. Then edge boundaries are divided into simple straight lines and curved ones, and they are related each other by using generic relations such as corner and smooth join qualitatively, without quantitative information such as length and angle. Since these features are viewpoint invariant, a robust recognition technique to occlusions, noises and skew in the image under the perspective projection is realized.

Furthermore, it is implemented on PC cluster with a dynamic load balancing technology to increase processing efficiency under varying load conditions.

Demonstration

A method for detecting target image frames from a movie that include the specified trademarks is demonstrated. Input image frames are distributed to each processor on a PC cluster. According to the index of detection result, it can be distinguished easily whether the specified trademark is included in the frame or not. When it is detected, its reliability is shown in a graph for each frame. So, user can verify the recognition result with the image frame by pointing a certain position on a graph with one mouse click.

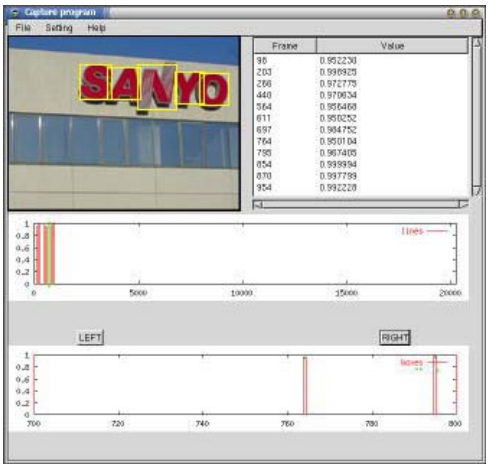

Fig. 1 : System overview

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High Performance Communication Processing Technologies: Comet

Parallel Network Server

Parallel and Distributed Systems Fujitsu Laboratory

Description of the Achievements

A high performance and protocol adaptive network Processor "Comet NP" brings safety and high speed Internet.

Significance of the Achievements

New Applications are supported by safety and high speed Internet

◇ A high speed security communication (business, medical and governmental applications)

◇ A high performance clustering computer system

- Using commodity hardware, we can always get a high performance computer system with reasonable cost.
- It will be able to grow to the world wide scale by the Internet connection.

◇ A high quality video streaming (TV conference)

Technical Developments

The Comet technologies achieved over-Gbps speed internet communication as the result of these total improving approach of protocol processing.

◇ A network processor "Comet NP"

- The Comet NP distributes data to the "hardware function blocks" as soon as data arrived, and realizes high performance and flexibility.

◇ A network adapter which equipped Comet NP

- It works independently of the OS scheduling.

◇"Comet VIA" a efficient data handling scheme

- Application programs send data directly to the network adapter.

We also developed prototype application systems of high performance Internet.

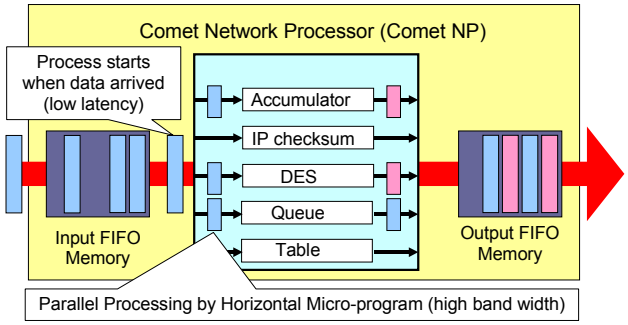
◇ Internet PC cluster system

- SCore-D for the clustering software which is developed by Parallel and Distributed System Software Laboratory, RWCP.
- PM/Comet: We ported a user level high performance communication library to the Comet.

◇ Digital Video over IP

- A bidirectional communication of high quality video streaming trough the Internet

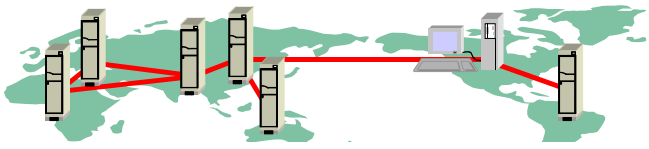
◇ High performance IPsec processing



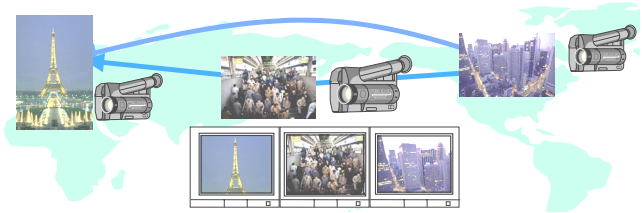
Data Processing of Comet NP

Demonstration

- A Internet PC cluster



- A high quality, secure video streaming system: Comet DV/IPsec



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Similar Sentence Search System

Clustering Middleware for Server Applications

Parallel and Distributed Systems Sumikin Laboratory

Description of the Achievements

Carrying out a development of server applications can be made efficient by adopting *SORB* middleware, which supports facilities for clustering and fault-tolerance to applications. A clustered similar sentence search system has been built using an existing search library *K-Tech Search II* in the demonstration.

Significance of the Achievements

Large processing power from parallelization has recently been demanded for searching documents, because flexible and complicated algorithms such as similar sentence searches are employed. SORB middleware helps build such parallel applications and adds fault-tolerance with redundancy. Using SORB, one can carry out a task of building parallel applications in a short time and at low cost. Programming with SORB is easy, because it has a similar usage pattern to the popular Java RMI.

Technical Developments

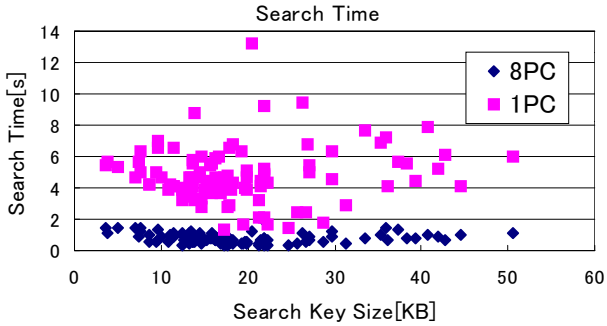
SORB is a Java ORB system enhanced by facilities of *stub management*, *reliable object management*, and *group execution*. The stub management enables repositioning of a remote object to which a stub refers. The reliable object management duplicates modified remote objects to make them durable. Once a fault occurs, remote objects are recovered from their copies, and the stub manager corrects the references to them. A group execution invokes a method on multiple remote objects simultaneously. The same interface as singular execution can be used in group execution. In addition, SORB can utilize the SCore's fast communication layer PM, which we have ported from the Linux to the Windows environment.

Demonstration

The demonstration system consists of 11 PCs, and searches through the Japanese patent document base from 1998 to 1999. Nine PCs are used for search engines, and two are for the front-ends and run WWW servers. One of the nine PCs is reserved for spare in a hot stand-by state. Also, one of the two front-ends is in a hot stand-by state. A fault on a single PC will be overcome by restoring all of the data by shifting the responsible patent data in order, because each PC holds spare patent data from a previously numbered PC as a backup,

The figures below show the overview of the system and the performance in searching similar documents. The performance figure shows the speed-up is roughly proportional to the number of PCs.

Overview of the similar sentence search system.



Performance in searching similar documents.

Inquiries

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High-Speed Switch for PC Network

Optical interconnection for the large-throughput data bus system

Optical Interconnection Hitachi Laboratory

Description of the Achievements

RHiNET-2/SW and RHiNET-3/SW are compact and high-speed network switches for high-performance PC-network-based parallel computing system RHiNET (RWCP high-performance network, Fig. 1). RHiNET-2/SW enables 8-Gbps x 8-port switching throughput (the aggregate throughput is 64-Gbps, Fig. 2), and RHiNET-3/SW enables 10-Gbps x 8-port larger switching (the aggregate throughput is 80-Gbps). These two switches enable high performance parallel computing in a distributed PC network environment.

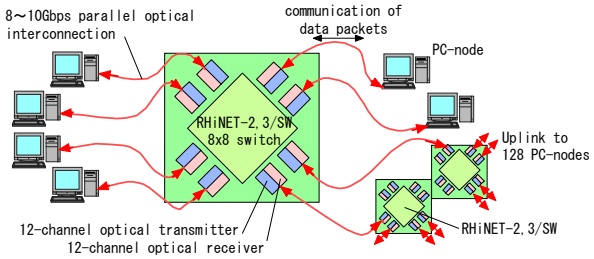

Fig. 1 High-speed PC network using RHiNET-2, 3/SW

Significance of the Achievements

1. RHiNET switches enable commercial PC-based parallel computing system in distributed environment.
2. These packet switches provide 8 Gbps ~ 10 Gbps very high-speed optical node-to-node communication.
3. These packet switches support 100 m ~ 1 km long transmission length.

Technical Developments

1. High-speed CMOS-LSI chip set
   We produced CMOS crossbar-packet switch LSIs (8-Gbps ~ 10-Gbps x 8-port for RHiNET-2, 3/SW). The aggregate throughput is 64 Gbit/s ~ 80 Gbit/s per chip. These chips enable very high-speed and low-latency switching for RHiNET. Additionally, RHiNET-3/SW uses deskew-LSIs for the skew compensation in a long (1km) optical fiber ribbons.
2. Optical Interconnections
   RHiNET-2, 3/SW use 800-MbpsMbps ~ 1.25-Gbps x 12-channel parallel optical interconnection. They enable high-speed and long-transmission-length (100-m ~ 1-km) data transmission with a small device size.
3. High-speed and high-density packaging technology
   RHiNET-2, 3/SW provides high-speed packet switching with compact packages (Fig.2). We developed high-speed and high-density packaging technology to overcome the loss, crosstalk, and noise in high-speed signaling.

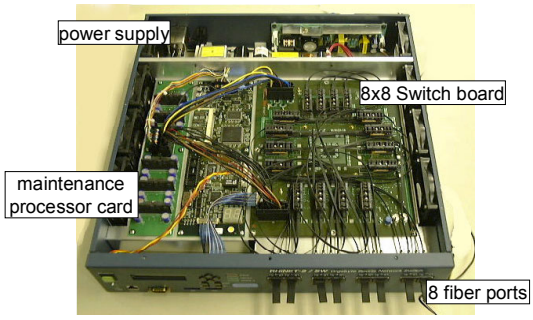

Fig. 2 RHiNET-2/SW

Demonstration

1. 64-node large-size parallel computer (RHiNET-2)
   We demonstrate a parallel computing with 64 PC-node and 16 RHiNET-2/SWs. It shows high-speed and reliable optical network performance in a large-size, parallel computer system (Fig.3).
2. 8-node parallel computer (RHiNET-3)
   We demonstrate a parallel computing with 8 PC-nodes and RHiNET-3/SWs. It shows high-speed (10 Gbps) networking in a practical parallel computing system.

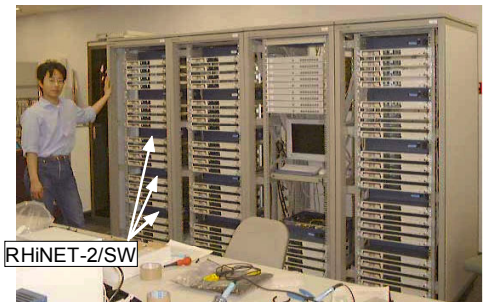

Fig. 3 RHiNET-2: 64-node parallel computing system.

Inquiries

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Optical-Interconnection Intellectual-Property

Low-power-consumption optical interconnection

Optical Interconnection NEC Laboratory

Description of the Achievements

We have developed a network switch LSI of the RHINET. It has sixteen 2.5-Gb/s (40G) full duplex ports, directly connected each other via optical fiber. A new technology called OIP (optical-interconnection intellectual property) has been developed to make the optical-fiber-connected LSI. OIP is an optical input/output (I/O) block as the IP* of a system LSI. It is composed of hardware and software components: an optical/electrical LSI package and library files used in LSI design, respectively.

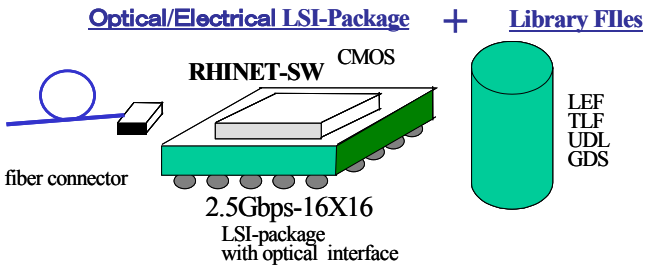
*IP: Intellectual Property is a certain functional block or circuit that is used repeatedly in designing a large system LSI to shorten the design time.

Significance of the Achievements

OIP enables us to use an optical interface in an ordinary design environment for cell-based ICs. An optical interface offers superior speed and throughput compared with an electrical interface. It can solve the I/O bottleneck of the system LSI. Large-scale system LSIs, such as switches, routers, and CPUs, often suffer from insufficient I/O throughput. OIP supplies those LSIs with high throughput, which cannot be achieved by an electrical interface.

Technical Developments

We have developed a very small photonic/electrical tagged interface (PETIT). It has 10-Gb/s full-duplex connections in a size of only 8 mm square. Laser diode (LD) and photodiode (PD) arrays, receiver and driver ICs, and optical connector receptacles are integrated on a ceramic substrate. The LD is a four-channel VCSEL array. Each channel can carry 3.125 Gb/s of data. Low power consumption of 1.2 W is achieved by using the low-power VCSEL array. PETIT is so small that it can be mounted directly on the LSI package, which houses optical-fiber-connected LSIs.



We have prepared library files for the optical I/Os. Using them, one can use the optical interface in an ordinary design environment for a cell-based IC. This is significant because optics and high-speed electronics are often totally unfamiliar to system designers. OIP removes the high barrier system designers usually face in using optical interconnection.

Demonstration

We will demonstrate a switching system using the OIP-LSI. The LSI is in a standard 352-pin BGA package. However, PETIT is mounted on an interposer. It supplies 16 x 2.5-Gbps high-speed optical inputs and outputs. Because all high-speed signals are carried optically, electronic signals via print wire board (PWB) are low speed. Therefore, eight switch LSIs can be mounted on a single PWB. The switch connects lack-mounted PCs/

Inquiries

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RHiNET

Interface Technology for Low Power Dissipation Optical Interconnections

Parallel and Distributed Systems Architecture TRC Laboratory

Description of the Achievements

RHiNET is a LASN (Local Area System Network) which realizes high performance parallel processing by connecting computers distributed on one or more floors of a building. For high-speed data communication and connection flexibility, optical interconnections driven at 8 ~ 10 Gbps are used. Specially designed network interfaces and network switches, in combination with high speed optical interconnections, will support fast communication that realizes high performance parallel processing in a local area distributed computing environment.

Significance of the Achievements

These days, because of the rapid progress of optical technologies, communication bandwidth of networks is increasing dramatically. The increasing ratio of the network bandwidth is larger than that of computer performance. Therefore, the structure of networks for local area should be changed to accommodate such high bandwidth.

RHiNET is a prototype of such network. Specially designed network interfaces and network switches, in combination with high speed optical interconnections, will support fast communication that will realize high performance parallel processing in a local area distributed computing environment.

Computers can be connected with up to 10Gbps bi-directional links. The link length can be extended up to 1km, and the topology of the network is not restricted, while no data is discarded even if the network is congested. The latency of the network is smaller than conventional LAN such as Ethernet in the order of 10.

Technical Developments

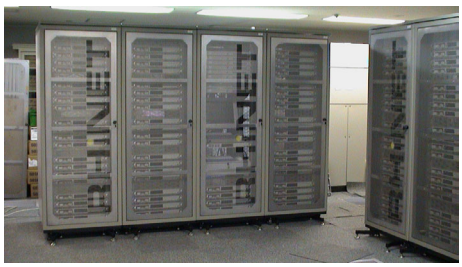
A network processor for user-level zero-host-copy communication is developed. Martini provides high-speed remote DMA by hard-wired logic, and flexible communicating functions by an on-chip processor. The switches, RHiNET-2 and RHiNET-3, use asynchronous wormhole routing and micro frame based short packet switching respectively, to provide reliable, low-latency, non-blocking communication. A large embedded memory provides a large buffer that supports nearly free topology design without deadlock or discarding data.

Demonstration

Following three systems are shown:

-A RHiNET-2 system with 64 PCs.

8Gbps links and RHiNET-2/SW switches connect 64 SMPs.



-A RHiNET-3 system with 8 PCs

10Gbps links and a RHiNET-3/SW switch connect 8 SMPs.

-A DIMMnet-1 system with 4 PCs

Optical links and a switch connect 4 PCs.

Inquiries

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Heterogeneous Parallel and Distributed Computing

Heterogeneous Parallel and Distributed Computing Systems

Parallel and Distributed Systems NEC Laboratory

Description of the Achievements

We developed a seamless parallel programming system, which allows programmers to rewrite existing sequential programs to parallel programs for heterogeneous systems, which consists of several kinds of computing resources connected via a high-speed network, easily and efficiently.

Significance of the Achievements

It is possible to develop large scale and complex application easily without deep understanding for underlying computing environment, such as combination of a vector supercomputer SX-4 and a scalar parallel computer Cenju-4.

Technical Developments

1) Unified programming interface based on HPF(High Performance Fortran): The programming system provides a unified programming interface which allows programmers to deal with both programming for individual computer and programming over heterogeneous systems in a single programming interface easily.
2) Automatic parallel and distributed program generation: The programming system accepts an ordinary Fortran program, analyzes it to decide how to assign data and computation to each processor, inserts required communication codes and finally generates a parallel and distributed program executable on a heterogeneous system.
3) Run-time optimization: It is possible to apply some optimizations to a program while it is running using several kinds of information collected at run-time. The information includes program information, which cannot be obtained at 'static' compile-time, and status of system resource, such as memory usage and CPU load.

Demonstration

To show effectiveness of our approach, the following demonstrations will be presented using two practical heterogeneous systems: a Score cluster/Cenju-4 coupled system located at booth C-3 and a SX-4/Cenju-4 coupled system located at remote site.
1) Interactive parallel programming with the programming system: several capabilities of the system which support programmers to rewrite existing sequential Fortran programs for heterogeneous systems through graphical user interface (GUI) will be demonstrated.
2) Run-time optimization using dynamic information: effectiveness of the run-time re-compilation and the load balance will be shown by real time animation.
3) Parallel and distributed execution of a practical application: we developed a parallel and distributed program based on an AB INITIO MO calculation (Hartree-Fock method) as a practical application which can run on a prototype heterogeneous system.

Inquiries

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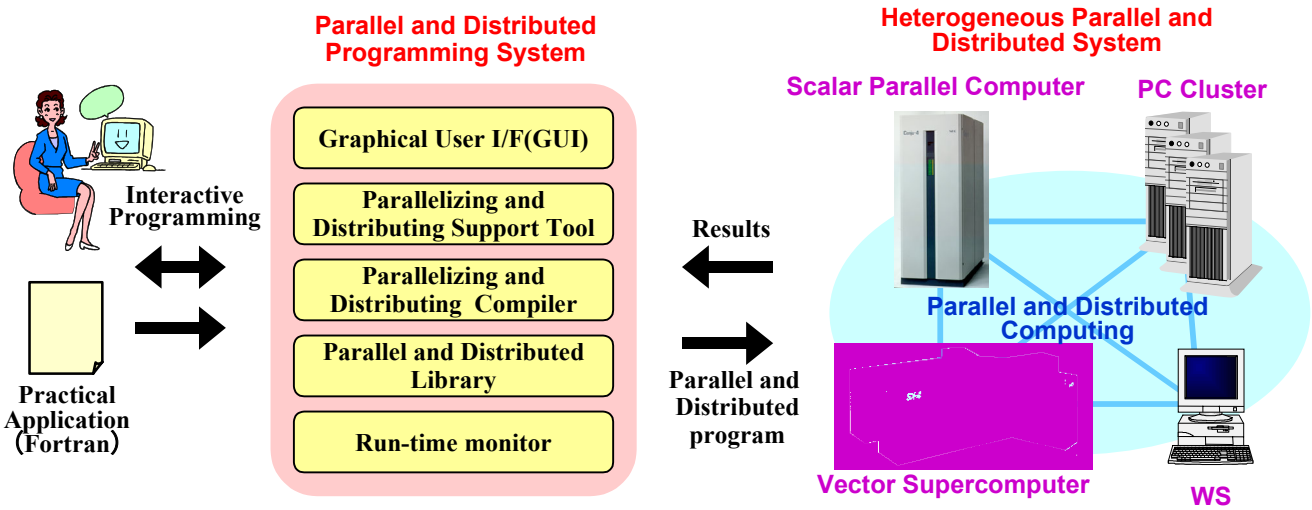


SCore Cluster System Software

Basic Software on Cluster Systems

Parallel and Distributed Systems Software TRC Laboratory

Description of the Achievements

In the replacement of a traditional supercomputer, a cluster system, commodity computers are connected with high-speed networks, is now accepted by users. The SCore system software , shown in Figure 1, utilizes the power of such a cluster and makes it a supercomputer. To evaluate the SCore system software scalability and to support application developments in the industry, RWC SCore Cluster III, which consists of 1,024 processors, was built (Figure 2). SCore Cluster III marked 548 Gflops as the linpack benchmark result, using 960 processors. It is ranked the 36th fast supercomputer in the world according to the TOP500 organization.

Significance of the Achievements

Inexpensive PC clusters with SCore enables the users new application developments such as real-time simulators, real-time volume rendering, and bioinformatics. The PC consortium was established by computer vendors, which announced the SCore business, so that the SCore development is continued by the consortium.

Technical Developments

- High Performance Communication Library

The PMv2 high performance communication library is dedicated for cluster computing. PMv2 is realized on top of Ethernet, Myrinet, and so on. PMv2 achieves more than 140 Mbytes of bandwidth and around 15 micro second round trip time using a Myricom Myrinet network. PMv2 for Ethernet utilizes not only one Ethernet link, but also more than two links. The impact of communication performance is shown in Figure 3. MPI-LAM, based on TCP/IP, is also shown.

- Efficient Computer Management and Singe System Image

The SCore-D global operating system coordinates computers so that the execution of parallel applications is scheduled efficiently at the same time in those computers (this scheduling is called gang scheduling). SCore-D makes a cluster as if it were a single supercomputer.

- Higher Usability and Availability

SCore-D realizes single/multi user mode and batch job processing mode. It provides the checkpoint and restart function for high availability.

- Seamless Clusters Environment

The SCore software supports from a small-scale cluster using Ethernet to a large-scale cluster using Gigabit Ethernet or Myrinet where the users may use those systems seamlessly.

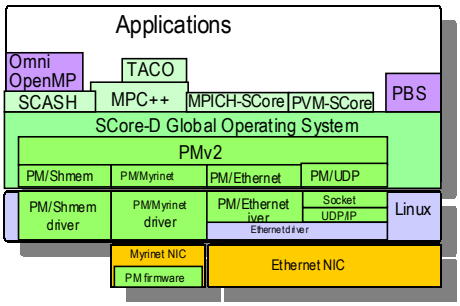


Figure 1. SCore Cluster System Software

512 Compute Hosts + 4 Server Hosts
NEC Express5800
Dual Pentium III 933MHz
512 MB of main memory
Two 9 GB local disks
Network
2 Fast Ethernets
Myrinet-2000

Figure 2. SCore III

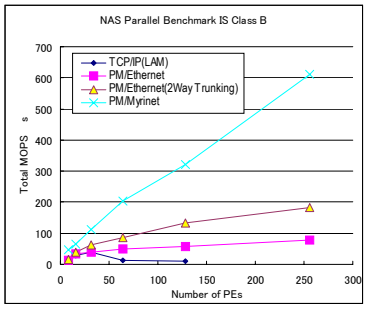


Figure 3. NAS Parallel Benchmark IS result

Demonstration

The best way of a system software demonstration is to show real user application demonstrations using the system software. Thus, a small-scale cluster based on the same technology of SCore IIII is brought to the exhibition so that the cluster serves the computer power to other laboratories, such as GMD and Toshiba.

For inquiries, please contact to:

The SCore development is continued in the PC cluster consortium. For more information, please visit the following URL: http://www.pccluster.org/

Parallel Data Mining System

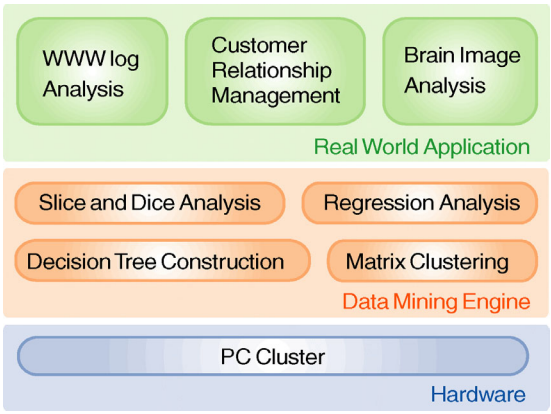
Parallel and Distributed Data Mining

Parallel Application Toshiba Laboratory

Description of the Achievements

We have developed a parallel data mining system which discovers knowledge from large scaled real world database. We aim to apply parallel processing technology to the wide range of business field.

Our system is implemented on the PC cluster with a large storage and Score system developed at TRC Laboratory. Various data mining algorithms are parallelized on the system, which enables terabyte mining within several hours. Our platform achieves more than ten times of cost-performance enhancement compared with supercomputers and large scaled servers.



Significance of the Achievements

Our system enables analysis of large scaled data on a cheep platform, which can be expected to widen the market of data mining system toward middle and small scaled companies. Especially, size of WWW access log is growing rapidly and its effective analysis is getting important for the success in internet business. Our system can provide powerful solutions for small scaled internet business players.

Technical Developments

1. Decision Tree Construction

The decision tree algorithm is one of the most widely used algorithms in the data mining. Conventional parallelization of decision tree construction is not efficient because of the load imbalance and disk access overhead. Our parallelization method solves this problem by dynamically balancing the load with considering the memory size in order to minimize disk access. The performance evaluation shows that our method can achieve 2.8 times of speedup comparing with the conventional algorithm.

2. Parallel Slice and Dice Analysis

We have developed a new classification algorithm named slice and dice analysis. This method finds characteristic distributions of records that satisfy a given condition on multi-dimensional database. Our method searches all the projections of the multi-dimensional database, and generates rules that correspond to the characteristic spaces. We have also parallelized the slice and dice analysis on the PC cluster. The effect of parallelization is about 14 times speedup with 16 nodes PC cluster.

3. Matrix Clustering

We propose a new data mining method named Matrix Clustering for CRM (Customer Relationship Management). Matrix Clustering is defined to extract a dense sub-matrix from a sparse binary matrix by exchanging rows and columns. We have developed an efficient algorithm named ping-pong algorithm for matrix clustering. The ping-pong algorithm iterates marker passing between rows and columns with pruning. The algorithm is applied to WWW access analysis to find characteristic page clusters and to predict user's preference.

Demonstrations

We demonstrate our parallel data mining tools, featuring decision tree, slice and dice analysis and matrix clustering. They are invoked from common GUI of data mining tool.

We analyze POS data and WWW access log data, and extract hidden knowledge from these data.

For parallel efficiency of our data mining engines, we demonstrate efficient parallel execution of decision tree construction and slice and dice analysis on the PC cluster. We also demonstrate WWW access log analysis.

As the application of data mining, we demonstrate the personalization of WWW access by using our data mining tools.

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PAPIA: Parallel Protein Information Analysis System

Construction of Parallel Protein Information Analysis system

Parallel Application TRC Laboratory

Description of the Achievements

Protein information includes the sequence and the structure (*ex*. coordinates), and a large amount of protein information is available for protein research. The PAPIA cluster was built based on PC cluster II, which developed by Parallel and Distributed System Software Lab., RWCP, to process such a large amount of information at high speed. Parallel Protein Information Analysis (PAPIA) system was constructed on the PAPIA cluster. PAPIA system consists of the following subsystems, which are able to search quickly by parallel processing technologies.

(1) Protein similar structure search
(2) Protein homologous sequence search
(3) Protein multiple sequence alignment
(4) Protein secondary structure prediction
(5) PDB-REPRDB

The PAPIA system is available on World Wide Web (http://www.cbrc.jp/papia/).

Significance of the Achievements

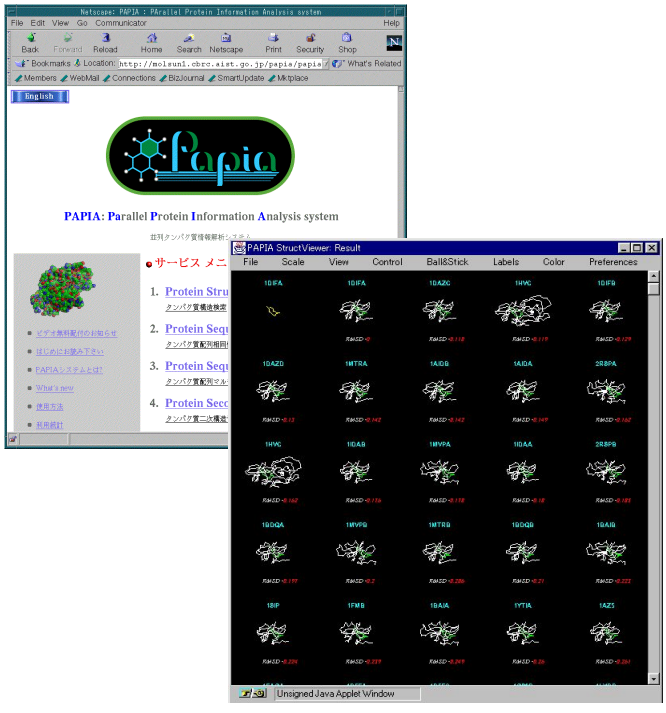
(1) The researcher of bioinformatics and biologist are able to use the high-speed protein information analysis by the parallel processing readily through the Internet.
(2) The effectiveness of the parallel processing was shown to a large amount of data processing in this field.
(3) The PAPIA system is accessed from more than 70 countries since the publication to external researchers though WWW.

Technical Developments

(1) PAPIA system was developed by using a C++ library (PAPIA library), which includes commonly used program modules for protein analysis in order to rapidly and efficiently develop application software.
(2) A high-speed database search of on a memory was achieved by putting a large amount of protein data in the wide memory space of the PC cluster.
(3) The PAPIA system adopted the WWW interface so that the user may easily analyze protein information from all over the world through the Internet.

Demonstration

PAPIA system (*i.e.* protein similar structure search, protein homologous sequence search, protein multiple sequence alignment, protein secondary structure prediction and PDB-REPRDB) is introduced by operating through WWW.



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PROMISE Data Parallel Programming Environment

Development of a High-Level Parallel Programming Environment

Parallel and Distributed Systems GMD Laboratory

Description of the Achievements

PROMISE enables scientists and engineers to write parallel programs with an effort comparable to that of sequential programming. Using the PROMISE environment, application developers maintain a problem-oriented view when writing parallel algorithms. For the programmer there is no need to deal with the low-level and error-prone aspects of parallel programming. This reduces the overall cost of developing and maintaining parallel software.

The PROMISE environment solves the technically challenging problem of providing high-level parallel programming concepts without sacrificing efficiency.

Significance of the Achievements

PROMISE covers a broad class of scientific application. It supports not only regular, static applications but also irregular and dynamic problems. In particular, the following applications can be elegantly implemented.

- adaptive finite element and finite volume methods,
- algebraic multigrid methods,
- graph algorithms.

PROMISE is highly portable. PROMISE programs run on super computers (NEC, Hitachi, Cray), PC clusters (RWCP, Beowulf). Both distributed and shared memory systems are supported.

Technical Developments

The core of PROMISE consists of two parallel libraries, Janus and Mosaik.

The C++ library Janus provides template classes and generic algorithms to model distributed data structures. These abstractions are based on high-level concepts *domain*, *domain function*, and *relation*. Lower level details of the program like local index schemes and process communications are automatically handled by Janus.

Communication is expressed by operations whose semantics is derived from matrix-vector multiplication. There is no need for explicit message passing when using these Janus primitives. With this communication paradigm the programmer meets a Janus typical structured programming style which in fact covers all the needs of data-parallel programming.

Janus can efficiently utilize both distributed memory architectures and shared memory systems. JADE (Janus Distributed Engine) is a small port package of Janus that has been interfaced to MPI, the Multi-Threaded Template Library (RWCP), and OpenMP.

Mosaik, the second PROMISE library, has been designed to map program data to the processing nodes by means of their geometric coordinates. Its algorithm, referred to as Balanced Hypersphere Tesselation (BHT), is developed by the PROMISE group, too. BHT is an efficient parallel and adaptive clustering method based on generalized vector quantization. Mosaik is appropriate for nearest naighbor communication, especially for dynamic repartitioning of adaptively modified structures.

Demonstration

- Refinement and coarsening of triangulations for adaptive finite element methods
- Vertex–centered finite volume method for convection–diffusion problems on adaptively refined quadrangle meshes
- Algebraic multigrid methods
- Graph-theoretic algorithms like Bellman–Ford and Ford-Fulkerson
- Balanced Hypersphere Tessellation

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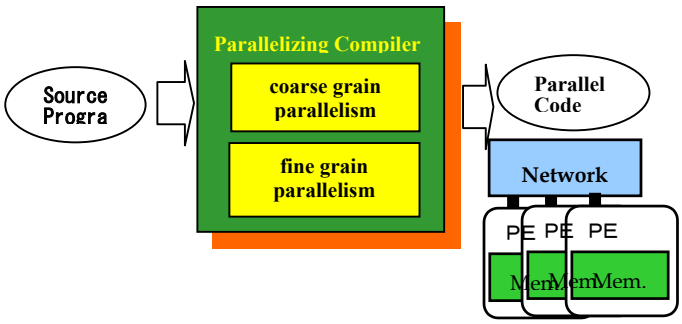
Compiler Approaches for Exploiting Various Levels of Parallelism

Parallelizing Software Techniques for Multiprocessors

Multi-Processor Computing Fujitsu Laboratory

Description of the Achievements

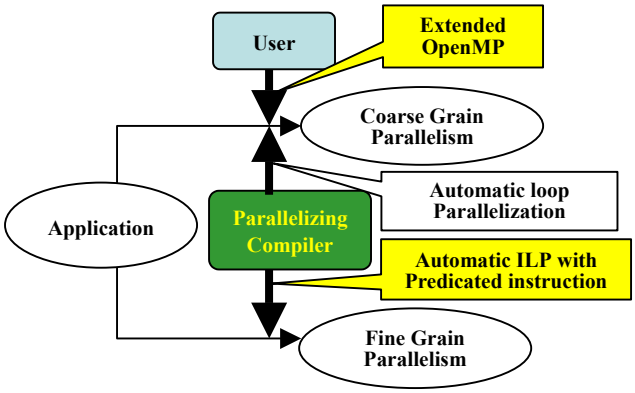
We developed a prototype parallelizing compiler which can exploit a wide range of parallelism from coarse grain procedure to fine grain instruction level parallelism (ILP) to maximize the performance of vector type Distributed Memory Parallel Computers (DMP). We proposed extensions of OpenMP API for the vector DMP environment. The compiler can also increase ILP by generating the predicated instructions and scheduling the instructions with the register allocation consideration.



Vector Distributed Memory Parallel computer

Significance of the Achievements

The users needed to write the message-passing style programs to distribute the data on each memory to use the vector DMP efficiently so far. By using the extensions of OpenMP API we proposed, the user can develop the parallel applications on the vector DMP easily and efficiently. Besides the compiler automatically generates the predicated instructions and increases the ILP so that the user doesn't need to worry about fine grain parallelism. These features lead the vector DMP to be used in various application fields.



Various Level Parallelization

Technical Developments

The key concepts of the extensions of OpenMP for vector DMP are a processor group and an index distribution. The processor group abstracts the processor resources where the program will be executed on and data will be distributed on. The index distribution maps the portion of data and computation to one of the processors. The experimental results on Fujitsu VPP700 show 65% of the best effort performance only with the directives. We also developed the compiler technique for increasing ILP. It considers the register allocation, the instruction scheduling and the predicated instruction generation at the same time. The experimental results show that speed-up of some programs is over 50%.

Demonstration

We explain our prototype compiler that can exploit both coarse grain and fine grain parallelism.

The key concepts of the extensions of OpenMP Fortran95 for vector DMP are introduced. The results of the experiments on Fujitsu VPP700 are presented.

We also explain the predicated instruction generation algorithm, and the relationship of the register allocation and the instruction scheduling, and show the experimental results on the simulator.

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Automatic Parallelizer using OpenMP

Development of Automatic Parallelization System

Multi-Processor Computing Hitachi Laboratory
Parallel and Distributed Systems Performance TRC Laboratory

Description of the Achievements

We have developed the compiler system, which transforms existing serial programs into highly parallelized OpenMP programs automatically and makes its output codes to run at high speed on various parallel computers. We have also developed the tuning system, which helps users to increase the degree of parallelism for their parallel programs.

Significance of the Achievements

- The users' burden for parallelizing existing serial programs can cut down.
- Highly parallelized programs using OpenMP, the standard parallelization specification, can be generated.
- OpenMP programs can run fast on various parallel computers on which OSs currently used widely, such as Linux, work.
- Users can be helped to increase the degree of parallelism for their parallel programs.

Technical Developments

Interprocedural automatic parallelization:
- Large parallel portions can be detected by using interprocedural automatic parallelization, which analyzes the whole program beyond procedure boundaries and detects parallelizable portions.
- Programs can be analyzed easily by using interprocedural constant propagation, which propagates constants to functions making those clones and evaluating expressions.

Portable multi-target OpenMP system:
- Omni OpenMP compiler and the runtime library enable OpenMP programs to run on wide variety of parallel computers from shared-memory multiprocessors to the SCore cluster systems.

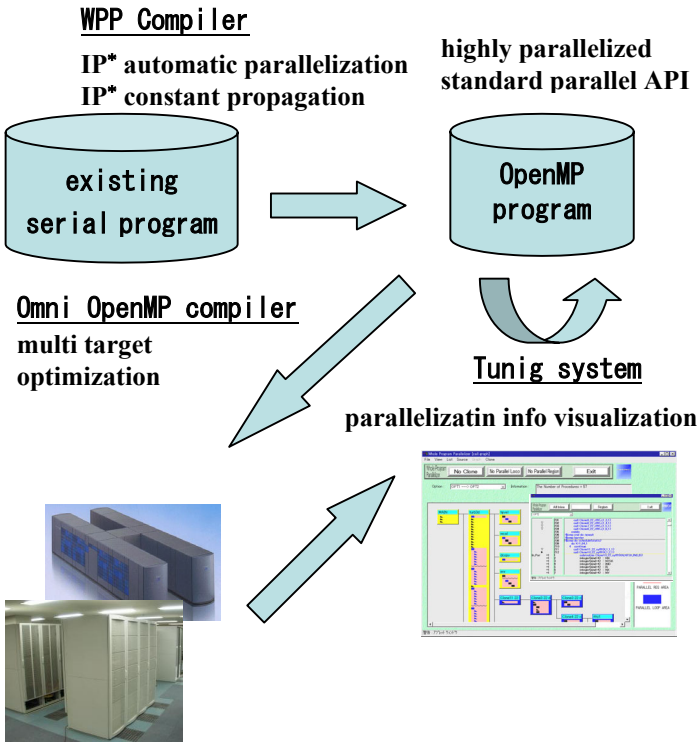
Parallelization information visualization:
- Parallelization over the whole program can be visualized by using the call graph, which displays loops and call sites on function nodes.
- Performance defects can be easily detected by using parallel execution status visualizer, which supports the time-line representation of parallel events and the magnification/reduction of the image.

Demonstration

We demonstrate that a serial program is transformed into an OpenMP program automatically using WPP compiler, the OpenMP program is compiled into the code which can be run on a shared-memory multiprocessor with 4 CPUs using Omni compiler, and the code is executed on the computer. We also execute the original serial program on the same computer, and show that the OpenMP program runs faster.

Moreover, we demonstrate the tuning system, which displays the parallel execution status and the parallelism of a program graphically.

***IP: Interprocedural**



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Intermodal Interaction Systems

Research on Interaction by Integration of Information

Interactive Intermodal Integration Lab, RWI-Center, AIST

Description of the Achievements

Technologies are developed for interactions in the real world between human and artifacts using speech and visual information.

In order to realize natural interactions between human and system, it is difficult to describe information in the real world explicitly. For this problem, research on learning through integration of speech and visual information, named as "Intermodal Learning", has been conducted.

A method of detecting filled pauses (lengthened vowels) in natural speech interactions was developed. Using this method, a new speech interface function, called "Speech Completion", was developed which helps a user enter a word or phrase by completing (filling in the rest of) a phrase fragment uttered by the user.

Furthermore, prototypes of multi-modal interaction systems and multi-modal interaction leading script were developed. Research on gesture recognition using a statistical method was conducted. Interactions between human and system were collected and analyzed.

Significance of the Achievements

Research and development on learning through integration of speech and visual information enable to obtain information in the real world which was difficult to describe explicitly. They also enable learning through interactions.

Current speech-input interfaces have not fully exploited the potential of speech. Our "Speech Completion" is a first step to make full use of important roles nonverbal speech information plays in human-human communication.

Works on the multi-modal interactions have produced various element technologies for the interaction between human and system. Phenomena on such interactions were also revealed.

Technical Developments

In the research on intermodal learning, a new framework on the learning with integration of speech and visual information was proposed. The integration of different sources of information is common in the human acquisition of language. This research shows a new direction for its realization in the technological domain.

Filled pauses (lengthened vowels) occur frequently in spontaneous speech. They provide valuable roles, such as keeping a conversational turn, in human dialogues while they tend to cause errors in speech recognition. A new method detecting filled pauses was developed by using bottom-up signal processing independent of language.

The speech interface function "Speech Completion" was developed. Even if a user cannot remember an entire phrase exactly, this function enables the user to enter its phrase by uttering its fragment and selecting one of completion candidates generated by filling in the rest of the fragment. By building an interface that displays candidates only when a filled pause is uttered, we enable a user to invoke this function intentionally and effortlessly.

Furthermore, development of prototype multi-modal interaction systems and the multi-modal interaction leading scripts enabled the system development more smoothly and flexibly.

Demonstration

We provide two demonstrations.

One is on the "**Intermodal Learning**", works on the learning through integration of speech and visual information. First, speech and some images are shown to the system. Speech (words) and corresponding images are given one by one and the system learns about the relationships between those two types of information. Next, when the system is asked using the speech (word), it replies with the learned image and word. When the system is asked by showing the image, it replies with the learned speech. By the interactive learning using speech and visual information, it makes possible to learn about the various information in the real world without specifying information explicitly.

The other is on the "**Speech Completion**". We build a prototype system retrieving the names of musicians and songs by using speech completion. In *forward speech completion* for a phrase whose last part is uncertain, a user gets candidates by uttering the first part with a filled pause on its last syllable. In *backward speech completion* for a phrase whose first part is uncertain, a user gets candidates by uttering the last part following a wildcard keyword with a filled pause on its last syllable. In *two-way speech completion* for a phrase whose middle part is only certain, a user gets candidates by uttering the wildcard keyword and the middle part with filled pauses on those last syllables.

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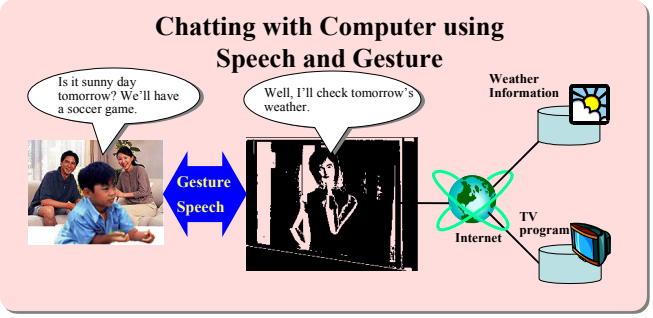
Chatting Computer

Nonverbal Multimodal Interface

Multi-Modal Functions Sharp Laboratory

Description of the Achievements

We have developed Multimodal Human Interface through which we can talk with a computer using nonverbal information like speech and gestures as if you talk with a friend of yours.



Significance of the Achievements

We have developed MAICO and UGNUN, prototypes of multimodal interface, to which users can talk with nonverbal information like speech and gestures. Our final target is to develop a truly human friendly interface. To realize this target, we propose the multimodal interface featuring the interaction with agents using nonverbal information.

These days, new products that fuse together IT and audio-visual technologies have been developed, and home electronic appliances have been broadly networked. In such days, our proposing multimodal interface should provide us with a new life style; for example, at home every family member can easily access to networked electronic equipment, and can get weather information or TV program through internet.

Further, in outdoor life, with the multimodal interface which enables us to communicate using gestures as well as speech, we will be able to use a mobile PC or a mobile telephone even in noisy environment. Interaction with a robot would be also possible.

Our multimodal interface should provide everyone, from children to aged persons, with a chance to access to the next generation's digital life.

Technical Developments

- Nonverbal information model, described with dynamical system, integrates the user's speech and motions and the system's rhythm, so that the CG agent can give back-channels at an appropriate timing.
- Dialogue model integrates the nonverbal information model and the verbal information model designed with frame, to realize the user's easy access to internet through the chatting with the CG agent.
- Multimodal dialogue corpus, a collection of spontaneous dialogues between two people, consists of speech waveforms, movie and motion data.
- Motion of CG model is based on the data of the multimodal dialogue corpus so that the motions such as nodding can be more real.
- All-in-one prototype system installs all of the dialogue model, gesture recognition method, CG model and speech recognition and synthesis.

Demonstration

- MAICO (Multimodal Agent Interface for Communication): You can chat with MAICO, and ask her to search for weather information or TV program through internet.
- GABRIEL (*aizuchi* prototype system): You can talk to GABRIEL who gives back-channels (*aizuchi*) at an appropriate timing.
- Multimodal Dialogue Corpus: Tools for constructing corpus and some dialogue data are demonstrated.

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Brain Activity During Recognition of Audio-Visual Patterns

Multimodal Information Processing in the Human Brain

Multi-modal Functions NTT Laboratory

Description of the Achievements

Which areas of the brain work when we recognize visual patterns, such as characters, and auditory patterns, such as voice? Although it is well known that the occipital lobes respond to the visual pattern, and that the temporal lobes work for the auditory pattern, the areas responsible for the simultaneous processing of auditory and visual stimuli are still unknown.

As shown in the figure, based on magnetoencephalographic data, we estimated the areas that were activated when the brain processed simultaneously the auditory and visual patterns. We also developed the estimation method that employed several quantitative and objective criteria, such as a goodness-of-fit, 95%-confidence volume.

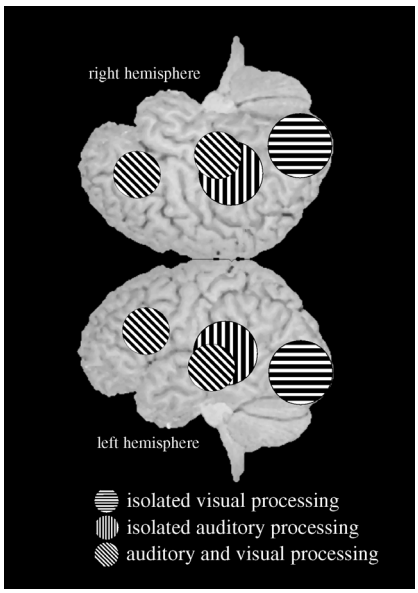

Figure:
The occipital area mainly works during the isolated visual processing, and the superior temporal area is mainly activated during the isolated auditory processing. When both visual and auditory stimuli are processed, the superior temporal area and the inferior frontal area are more strongly activated.

Significance of the Achievements

(1) We can apply our findings, such as the bilateral activation during the simultaneous processing of auditory and visual stimuli, to the development of a new information processing machine, which should be friendly with the human brain information processing.
(2) Our proposed method made it possible to analyze a large amount of data from a large number of subjects with the identical analysis parameters and the analysis criteria, resulting in the improvement of the data reliability.

Technical Developments

(1) We proposed the method that could calculate the activity peculiar to the audiovisual information processing.
(2) We developed the exhaustive local channel method to apply the identical analysis parameters to all of the data from all subjects engaged in all experimental tasks.
(3) We proposed an analysis method that employs several objective criteria to select the adequate localization results from all subjects' data.

Demonstration

In total, 3 displays are prepared. On the first display, we show the fundamentals of magnetoencephalography (MEG) ranging from Maxwell's electromagnetic equations to the actual measurement and analysis of MEG. You will easily understand how non-invasive MEG is important to know the brain activity of the normal person.

On the second display, we show the following several results about auditory, visual, and multimodal activity in the brain obtained in this laboratory.

(1) Visual experiments:
  (a) Brain activity during recognition of more than one visual pattern.
  (b) Active brain areas when the subjects recognize the Japanese characters.
(2) Auditory experiments:
  (a) How our brain responds to the cessation of the sound.
  (b) How we respond to the non-native speech sounds, /ra/ and /la/.
(3) Multimodal experiments:
  (a) Brain areas that are activated more strongly when the subjects recognize simultaneously both the visual and auditory patterns.

On the third display, we show the real-time analysis using the actual data taken from the individual subjects. First, the waveform analysis is performed to see the peak amplitude and latency. Second, we estimate the active area from lots of figures that look like meaningless at a glance. The estimated equivalent current dipoles are selected that satisfy the objective criteria. The selected active areas are projected onto the subject's magnetic resonance images where we can localize the active areas. It takes 1 to 2 minutes for this fundamental analysis.

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Adaptive Vision Systems

VizWear and Realtime Stereo Vision

Adaptive Vision Lab, RWI-Center, AIST

Description of the Achievements

A vision technology plays an important role in a interface system. The required vision function should be adaptive and interactive in a real-world situation. Prototypes of such adaptive vision systems have been developed in the lab and are demonstrated in RWC2001; 1) VizWear: A concept of human-centered wearable systems and services with visual sensing, visual interaction and augmented reality, 2) Realtime Stereo Vision: A trainable vision system which can recognize users and some objects in a scene and can communicate with users via basic movements including hand signs.

Significance of the Achievements

The systems empower people by building better interfaces with advanced machines. They enable us to communicate with machines friendly without mice and keyboards. They have the potential to assist us by continually sharing the same experiences with us by understanding the situations visually. Applications include devices for the disabled, navigation, repair instruction, visual remembrance agent, touchless control for appliances, and many others.

Technical Developments

VizWear: The system consists of a wearable client (including ultra small head-worn display, CCD ear-cam, and a mobile PC), a vision server (a PC cluster), and wireless LAN. A mobile PC in the wearable client captures and compresses each image taken by the wearable camera, using JPEG encoding, and transmits it to the vision server. The wearable client then receives and displays the output from the server. Although many vision algorithms are computationally heavy for existing stand-alone wearable computers, we have experimentally used our systems to run different vision tasks in (near) real-time in both a parallel and cooperative manner.

Realtime Stereo Vision: The system simultaneously utilizes the stereo disparity and optical flow information of realtime stereo gray multi-resolution images to recognize objects and their motion. The system determines the disparity and optical flow of a low density image and extracts regions in front of a certain depth. The three foremost regions are recognized by higher order local autocorrelation features and a linear discriminant analysis. With this process, the system recognizes the face and hand signs of users at the same time in realtime.

Demonstration

Three vision tasks of VizWear is demonstrated; Panorama-based annotation, 3-D annotation on recognized objects, and the hand mouse. Panorama-based annotation is a novel approach to sensing the wearer's position and direction, and to displaying video frames overlaid with 2-D annotations related to the wearer's view. The correspondence of live video frames to panoramic images is established by a fast and robust method of image registration.

We also demonstrate the Realtime Stereo Vision system. It can discriminate the face of a user, can recognize the simple gestures of the user, can smoothly learn a presented object by users, and can communicate with users from hand signs learned in advance.

VizWear

Realtime Stereo Vision

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Face and Facial Expression Recognition

Face and Facial Expression Recognition

Multi-Modal Functions KRDL Laboratory

Description of the Achievements

We have developed a set of techniques for face and facial expression recognition including face location, facial components detection, glasses detection and face warping. A robust and fast face location and precise eyes detection method is developed with the help of information fusion of motion, color and stereo features. Based on this technique, robust face recognition systems are developed, which use different models to characterize face features. We also developed a new method for personalized automatic facial expression recognition based on Facial Motion Graph.

Significance of the Achievements

The research results will help in developing next generation of human computer interface and humanoid robot.

Face and Facial Expression Recognition are very important capabilities of human vision system. Realizing some of these recognition capabilities by computers posses both bio-psychological and pragmatic importance. The research results of face and facial expression recognition will help in developing the next generation of human computer interface and humanoid robots.

Facial expression conveys a lot of KANSEI information, which is often very obvious to our instinct but we can seldom describe clearly. Face based person identification is a key to open a hall of applications such as personalized electronic services, security, people searching, etc.

Body and facial components extraction and tracking technologies can be easily adopted by applications such as virtual or augmented reality, people flow tracking, video conference and MPEG4 encoding.

Technical Developments

1. **Multi-scale face location.** It is very robust to lighting conditions and in complex background combined with a face tracking.
2. **Very fast face selection system.** It reduces considerably the search space by providing 99% of probability of presence of the good face within less than 5% of the complete database.
3. **Personalized facial expression recognition system**. Vector Quantization and Hidden Markov Models are used to understand general categories of facial expressions whereas continuous dynamic programming is employed to recognize a known person's expressions more accurately**.**
4. **Spectacles extraction.** We developed a system to detect if a person is wearing a pair of spectacles, and further to remove the frames from the face images. The paper has won a best paper award at SCI'2000.
5. **Face warping.** It is to obtain the frontal view face image from a slighted rotated single face image, by exploring the symmetry of the face.
6. **RealTrack.** It is a robust real time people tracking and identification system based on stereo vision. Comparing to normal monocular systems, it is more robust to background and lighting changes. Bodymetrics such as height can also be captured to help multi-modal person identification.
7. **Face recall by Gabor features.** We proposed a set of Gabor features to represent faces, and used the features on a neural network architecture for face recall. The method obtained outstanding performance comparing to a recent benchmark testing.

Demonstration

Here we show two systems. One is a system that can locate and recognize approaching persons. Another is a system that can understand a personalized facial expression.

1. **Face recognition system** A stereo camera system is used in the demo. If a person approaches the camera, the system will automatically locate the person's face and eyes and recognize him. The system includes modules of people registration and recognition.
   We also demo an integrated face location/recognition system, which is integrated into the mobile robot JIJO-II developed by NAIST. The system is robust to the lighting conditions, near-frontal face direction and facial expression.
2. **Facial expression recognition system.** Our facial expression system will be demoed on a separate computer with a camera. It first learns a person's expressions through a registration process. Then it can recognize his/her expressions by comparing the visual input with registered templates using continuous dynamic programming.

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Video Surveillance

Dynamic Scene Understanding

Multi-Modal Functions Mitsubishi Laboratory

Description of the Achievements

Demand of keeping and increasing safety and order of public space for anonymous users is getting larger. Video surveillance --- continuous inspection and collection of information of the scene based on visual data --- is one of the promising technologies. The video surveillance system we demonstrate consists of human tracker, the vision module and the host computer . The key technology we developed is the image processing method of robust human tracker. This method is based on the new image region segmentation technology. The vision module, another newly developed hardware, works as distributed "eyes" with built-in early and intermediate visual processing capability. All the data and information acquired and calculated in vision modules are transferred to the host computer where it is integrated and organized as surveillance information. As a whole, the surveillance system can collect human walk path and timing information.

Significance of the Achievements

The core of the newly developed image processing technology is a robust image region segmentation method and tracking of the image regions over movie frames. This can be applied to video surveillance systems in its extraction of useful information. In other words, This is a method of mining video data. When applied to security system of shopping area, for example, it becomes much easier to find out the particular events buried in huge amount of video data. It becomes also possible to measure flow of people in airports, in stations, in shopping malls and in department stores. These data are important to increase the efficiency and usability of the space.

In such intelligent video surveillance systems, the calculation must be executed in distributed manner because the system must be scalable against size of surveillance space. The newly developed network vision module is a neat implementation of distributed vision. In each modules, process from acquisition of image to calculation of tracking information is implemented. The heaviest part of image processing is executed just after the camera. This reduces required capacity of data transmission as well as calculation power of host computer.

Technical Developments

One of the fundamental problems of human tracking is that the targets are non rigid. Their body motion changes the target shape. In addition, the occlusion of target also changes its shape. It is not easy to model all these modifications of target shape. Our method of target tracking is based on image region segmentation and it is free from modeling of target shape. Tracking is realized essentially by detecting overlap of target regions between frames. In order to increase the stability of region estimation as well as tracking, identification of image regions are represented in probability distribution (PD) over region labels. The update rule of PD is so organized that region estimation is robust against region boundary incompleteness as well as frame difference of target shapes.

Demonstration

We demonstrate the tracking result by showing the online results of tracking people in the hall by using four of vision module. This helps the guests to intuitively understand what the intelligent video surveillance do and to clearly imagine the application fields we are proposing.

In order to describe the detail of the technology, demonstration by prepared video data is also done. This demonstration includes figures and movies that shows internal processes of the newly developed technology.

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Cyber Showcase

Versatile Modeling

Multi-Modal Functions Sanyo Laboratory

Description of the Achievements

In the recent advance of Web3D, electronic catalogues with 3D contents by using not only realistic CG but data obtained by scanning real objects. To realize the next generation human computer interaction system, it becomes very important to manipulate objects in such a virtual space as it is done by hand in the real world. Based on our finger motion recognition and tracking methods, objects can be manipulated in a virtual space without any special devices by using stereo images only. It means that users can pick up an item for sale from a showcase in a virtual shopping mall and look at it carefully in their hand.

Significance of the Achievements

In the field of electronic commerce and sales promotions, the way for displaying realistic objects in the virtual space is improved day by day. Here, not only how to display but manipulate of items for sale play a significant role. This is also important in the field of amusement (games) and CG design (ex. model inspection). By using our method, objects can be selected from a showcase by pointing and manipulated in a virtual space without any special devices.

Technical Developments

Here, the following two original technologies are emphasized.

1)Qualitative object recognition to get over small differences among individuals based on a "***Generic Model***" concept

2)Tracking without feature points such as corners

Since, conventional model-based approaches for object recognition uses precise geometric models for every object, it cannot be applicable in the real world. Our method can overcome this problem by using qualitative description of objects. And as for tracking, it can solve the problem by determining some tracking points automatically on the shape primitives for each finger to avoid so-called aperture problems.

Demonstration

By using stereo cameras to capture finger motion, the first finger and thumb are detected in the first frame and their 3D positions (pointing directions also) and orientations are calculated. Then, 3D motion parameters are calculated by tracking them frame by frame. Based on the calculated motion parameters, a gripper in the virtual space（Cyber Showcase）can be moved to select the target object. And after choosing an object, it can be manipulated. In this way, user can select an object from a showcase and manipulate it as it is in the real world.

Fig. 1 ：System overview

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Sign-Language Recognition System

Verbal Gesture Recognition

Multi-Modal Functions Hitachi Laboratory

Description of the Achievements

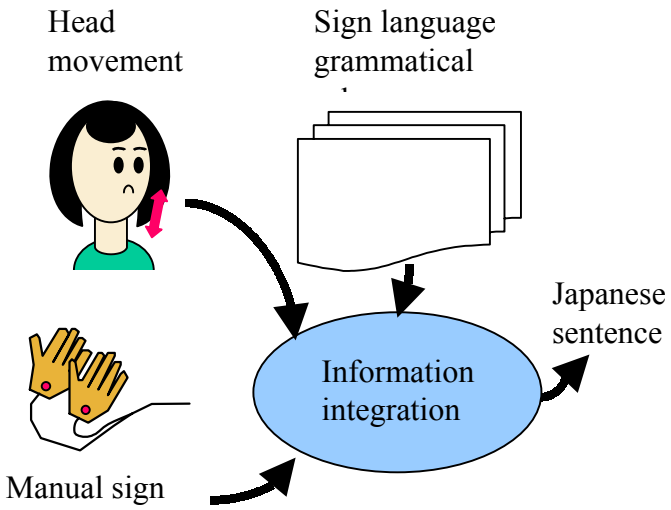
JSL (Japanese Sign Language) uses almost all parts of the upper body. Individual words are signed manually and grammatical information is expressed by head movement, eye gaze, mouth shape, eyebrows movement, facial expression, and posture. We have a opinion that JSL and Japanese are different languages. In this theme we have developed a database of JSL utterances by native signers, where each utterance associates a video segment with a detailed transcription. Based on this database, we have designed an algorithm and knowledge expression for JSL recognition. Regarding non-manual sign recognition, we have developed a system that recognizes head movement. Regarding manual sign recognition, we have developed an information service system with a sign language interface and performed a field test to confirm its effectiveness.

Significance of the Achievements

This technology can be applied to interpretation system from JSL into Japanese, which would support communication at public offices, travel agencies, and the like. It can also be applied to information service systems with a sign language interface as well as to sign language education systems. In the field test, which was carried out in Isahaya City from January to March in 2000, users found the system to be effective and very easy to use. This technology is not only socially relevant as a key technology for the advancement of barrier-free systems but also commercially relevant since reducing the digital divide is highly desired for further popularization of Internet.

Technical Developments

Our aim is computer recognition of sign language as a natural language. Our approach is characterized by the recognition of grammatical information expressed by head movement and the use of grammar rules in the process of linguistic transfer.



Sign Language Recognition System

Demonstration

(1) Sign language recognition system

Demonstration of seamless communication and highly precise recognition by integrating grammatical information expressed by manual signs and non-manual signs

(2) Information service system with a sign language interface

Demonstration of a multi-mode interface, where terminals can be operated using a touch panel, voice, and sign language. This is the system we field-tested in Isahaya city.

(3) Sign language education system

Demonstration of an evaluation function that recognizes the learner's signs and the a dialogue function that enables the learner to communicate with animated characters

(4) Annotated JSL corpus

Demonstration of JSL corpus, which was used to develop grammar rules

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Gesture Interface

Multi-Modal Interface for the Cross Mediator

Multi-Modal Functions TRC Laboratory

Description of the Achievements

A new realtime system of PCs is proposed to facilitate discussion by several users simultaneously. Each PC is of notebook size with a microphone and a CCD camera and provides spotting and recognition functions for both spontaneous speech and gesture

Significance of the Achievements

We have advanced a research of Computer Supported Cooperative Work (CSCW) to facilitate discussion by several users simultaneously. A CSCW system consists of personal computers (PCs) which are connected each other and each of which is of notebook size with a microphone and a CCD camera Each PC can share the same CG display which shows in realtime the present status of a task which should be done by several users

Technical Developments

The display shows a sequence of result of cooperative work in real time. Users may use spontaneous speech and gesture as input material because only meaningful parts in speech and gestures are spotted and recognized and used in each PC. A major benefit is that the system makes users to devote themselves to think how to perform the task with other users apart from the rules to enter the speech/gesture commands. We describe the implementation of the cooperative work space on a PC. This PC is called Multi-Modal PC (MMPC). A MMPC has a Pentium Processor (more than 233Mhz) for CPU, and uses Windows 95/98/2000 for operation system. We use TCP/IP protocol for communication among PCs. The network system is called the MMPC/Net and used for users in the remote places. Each MMPC consists of four modules, that is, 1) gesture recognition, 2) speech recognition, 3) integration and 4) display. The modules of gesture and speech recognition are based on a spotting method called Continuous Dynamic Programming (CDP) . The integration module is composed of a database of network type representing a task and a spotting method (called Continuous Automaton) for producing an output by integrating speech and gesture recognition with a database of network type. The output is transformed in real time to CG and synthesized speech at the cooperative work space to support discussion. Every module is updated frame-wisely synchronized with frame of results of speech and gesture recognition module. The single CPU is used for executing many modules. Therefore we must divide the modules into groups each of which is assigned by the suitable time of the CPU to realize realtime processing. There are modules such as 1) analysis and spotting recognition of speech, feature extraction and spotting recognition of time-varying image of gesture, 2) updating an automaton to integrate the task description and recognition results of speech and gesture recognition modules in order to provide outputs used for realtime CG display, 3) An example of CG display shows both the four latest status of the task for designing a house by producing the pictures showing arrangement of house, tree, pond, garage, etc and a CG agent with the face of which mouth movement realizes the movement of mouth of vowels included in the synthesized voice to communicate with the user.

Demonstration

1. Computer Human Interface based on Gesture and Speech
2. Gesture Interaction Mobile Robot

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Multi-Modal Information Retrieval

User-Centered Self-Organizing Information-Base

Information-Base Functions KRDL Laboratory

Description of the Achievements

We have successfully developed a set of complementary frameworks for multi-media content representation and retrieval. Specifically, we have achieved the following breakthrough from our research:

- Developed a unified solution for photograph indexing using image content and speech annotation.
- Developed a system for melody retrieval by humming.
- Developed a novel image representation and query paradigm called Visual Keywords.

Significance of the Achievements

Our photo retrieval technology provides a solution for indexing large quantity of photo using image content-based description as well as seamless speech annotation. The integration of these two approaches provides a very strongly coupled solution for photo indexing and retrieval, something that is lacking in current content-based retrieval system.

Our query-by-humming technology provides a solution for music retrieval. It can tolerate the errors in the humming by ordinary people. It can be applied to Karaoke, and help people find the desired song quickly. It can also help people to identify a song by the tune and make music purchase online. Music query-by-humming will have greatly impact on music society and industry.

Technical Developments

The Object Probes is a novel way of representing object labels. It makes use of both physical features and a manually formulated decision tree to efficiently and accurately classify objects in the scene. It has been determined that this approach performs better than the commonly adopted ANN classifier with same feature set. We introduce a methodology for image indexing using speech annotation technique to complement existing content-based techniques thereby promoting the reliability and use-ability of image retrieval systems. Speech recognizers, like *Dragon NaturallySpeaking* can be adapted to perform speech-to-text transcription. The use of structured speech as oppose to free form speech and the idea of using the N-best lists from the speech recognition output can further boost the accuracy of the transcription. The transcribed text is used to populate the metadata of the corresponding photograph.

One important issue in query-by-humming is to tolerate the errors in the humming. We have developed techniques to extract robust slope-based melody features from user's hummed query. By this approach, the users do not need to utter accurately every note of the hummed tune, and they are also freed to hum at any speed without using a metronome. We also invented a matching method to make the search of a large database efficient.

Demonstrations

Demo 1

The SmartAlbum application will be demonstrated on a Pentium notebook with a Java GUI. We show how the various modules of the indexing scheme contribute to the overall indexing task for a photo and how the photos can be retrieved using either a keyword-based query or using a graphic-based query that allows image searches to be performed using the object's spatial constraints.

Demo 2

In this demonstration, a system running on PC notebook can allow a user to search for songs by humming through a microphone. The intermediate features are visualized to demonstrate the feature extraction and search process. The features are matched with those stored in the database, which contain more than 1 thousand songs. The similar songs' titles are then displayed to the user.

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TV Commercial Analyzer

A self-organizing architecture for adaptive cognition of situations

Information-Base Functions Toshiba Laboratory

Description of the Achievements

Television commercials are composed of data with various modes, such as personalities in it, speeches and impressions caused by the picture itself. This system supports marketers and TV commercial creators to effectively analyze the commercials by creating a task-oriented information space through restructuring the data from viewpoints such as popularity of the commercials and brand separation.

Significance of the Achievements

The system supports a marketer to plan advertising strategies and a commercial creator to produce commercials. The system's functions include the following.

- Comparing a commercial-in-production with past commercials, the system suggests or automatically performs possible alterations to achieve desired effects.
- By identifying characteristics of a brand, the system supports a creator to keep consistency of the brand image. At the same time, the system suggests possible brand extensions that are likely to be accepted by the market.
- By identifying commercial components that are focused by the target consumers, the system gives creative hints to marketers and creators.

The system employs methods inspired by Kansei engineering to handle image data. The approach is important as a novel technique for marketing.

Technical Developments

In order to construct a framework where a way to perceive information from the outside, we have built perception modules for text / image / numerical data, that have the way of perception as parameters of the module. The parameters are purposefully adjusted using an evaluation function that is closely related to the task. In the case the evaluation function ranges discrete values, the parameters are adjusted in a similar way to clustering (Category-guided Adaptive Modeling, CAM for short). On the other hand, in the case the function ranges continuous or ordered discrete values, the parameters are adjusted by means of Smoothness-driven Adaptive Modeling (SAM for short), which is invented by us. The methods allow us to realize applications such as automatic customization and information browsing through stranger's eye, because a personal tendency of perception is materialized as the parameters. Furthermore, an information system that is capable of purpose-directed information reception and data processing because a way of perception is adapted to a particular evaluation function.

Demonstration

The following demonstrations are performed using TV commercial database consists of still images, texts and bibliographical items.

- The data is self-organized by means of SAM with the degree of the commercial reach. Suggested alterations for a newly entered commercial prototype, in order for it to have a similar advertising effect to a designated past commercial, are semi-automatically performed.
- The data is self-organized by means of CAM with the degree of brand separation. Suggested alterations for a designated commercial, in order for it to have a taste of a particular brand, are semi-automatically performed.
- The data is self-organized by means of SAM with the degree of the commercial reach for a particular class of the audience. The CM components that are effective for the class are extracted as the parameters. By applying them to the other commercials, how the audience perceives the commercial is visually displayed.

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Retrieval and Browsing for Large-Scale Image Archives

Metrization and Visualization of Image Information

Information-Base Functions Hitachi Laboratory

Description of the Achievements

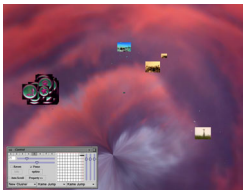
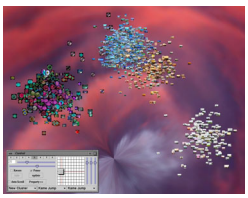
We have developed a retrieval and browsing system for large-scale image archives. The system performs retrieval and visualization based on the similarities between image data. It can be used the system as a standalone system or a front-end system connected to a conventional database system.

Significance of the Achievements

Our system provides user interfaces for searching and browsing that are appropriate for the scale of retrieved data and accommodate the needs of users. The user interfaces enable a user to access data buried deep in a database. This improves the reusability of an archive and makes "recycling digital data." The main application field is data management in media business (television stations, publishers, etc.) The system will also be very useful as the interfaces between multimedia-content-service companies and their clients.

Technical Developments

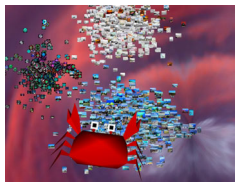
Spatio-temporal patterns of retrieval results

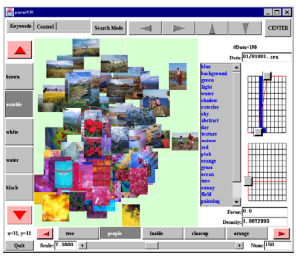
A user can brows up to 1,000 retrieved images in a three-dimensional space at once. The system enables the user to access data effectively by giving motion to the images. The retrieved images gather around query images and form *island universes*. The size of each image is given according to similarity between the image and a query image.

Walk-through method for information space

By using a "*Turtle*" moving freely in the space, a user can set the center of his observation field. By using a "*Crab*" revolving around the "*Turtle*," the user can get an objective view of the whole of data distribution.

Visualization using keyword axes



A user selects two keywords (e.g., people and sky) as two axes. The system visualizes retrieved images on two-dimensional space. Each axis represents the "suitabilities of assigning a keyword to retrieved images." The values of the suitabilities are estimated by using the image features. The system shows the keyword candidates, which are presumed to emphasize the differences in the retrieved images.

Demonstration

We show the effectiveness of our similarity-based image retrieval and browsing for a database containing 100,000 images. We also demonstrate registrations of still images, which are scene changes in a movie inputted by a video camera. The scene changes are detected automatically. If a user selects an image in three-dimensional space, an associated video clip is played.

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Integrated Semantical Information Retrieval Environment

Self-organization of Documents Information Space

Information-Base Functions Mitsubishi Laboratory

Description of the Achievements

We developed technology for a semantical information retrieval system that solves problems with conventional searching in which "the required information is not found" or "too much information is found for effective use". For example, to find out what newspapers reported on how an international dispute was solved, a user can search documents using "proposed solutions to dispute" as the search key. The new system can search the documents including "suggested an early end of the dispute" which does not match the search key by combining dependency relation and synonyms. Moreover, it minimizes the fake hits that come from documents that simply contain the search keys without dependency between them as can happen in full text searches. Furthermore, the our system make document clusters by the dependency of words and visualize clusters of similar meaning to give the user understanding of what kind of documents have been found.

Significance of the Achievements

What these results mean is that a user without sufficient knowledge or experience with the search topic can effectively search for information. The technology could be applied to information access support tools for the socially weak (elderly, etc.). (Information release tool for organizations and institutes such as city halls)

As an industrial application, the technology could be used to create information gathering tools for persons that have information access skills but no knowledge of specific fields. (Patent information search system for R & D, search system for online manuals and services reports in the maintenance business field, FAQ search system in the customer services field, etc.)

Technical Developments

We developed a pin-point search engine that performs highly accurate searches by identifying the dependency relation between words in documents with search key. The engine analyzes the information and dependency relation of Japanese words and, using XML, affixes a GDA (Global Document Annotation) tag set to the document.

We are proposing a PT-VSM (Poly-Term Vector Space Model) that expands on the conventional vector space model. It introduces dependency relation as dimensional expressions and dimensionally decompresses and compresses the thesaurus, ultimately forming semantical classification more than the co-occurrence of individual words. By combining full text searching, semantical classification that groups documents by PT-VSM and highly accurate searching, we have developed a syntactic search environment that enables effective interactive searches without requiring extensive knowledge or experience in the search topic.

Demonstration

A demonstration will be given on how the system analyzes sentence structure of data equivalent to one year's worth of newspaper articles (approx. 90,000 articles) and data on information processing patents (approx. 25,000 patents) for 1998 and searches for the structured documents using the GDA tag set.

The technology of semantical information retrieval will be explained and results shown for each of these data areas, using the following procedure.

1) Conduct a full text search. Show examples of searches with "no hits" and "too many hits".
2) Categorize search results using PT-VSM. Search through resulting categories and express dependency in terms of vector space, using an interface for graphically visualizing categories.
3) Transfer text in categorized document groups by PT-VSM to the pin-point search engine interface, analyze the sentence structure of that text, convert it to a key required to express the dependency relation of words and phrase, and conduct a highly accurate search.

The process of effectively narrowing down searches through interactive operation will be shown by returning to step 2 and imparting a pin-point search through a separate document group as well as searching through text found in documents for the search key.

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Interactive Multimodal Presentation

Design and Application of Multimodal Common Format

Language Integration Lab, RWI-Center, AIST

Description of the Achievements

This system performs interactive presentation of multimodal content containing audiovisual data, where the presentation changes in accordance with the interaction. The user is presented with a network representing the semantic structure of the relevant part of the content, together with audiovisual materials associated with the presented network. The user can operate on this network, which changes the importance of parts of the network and hence dynamically changes the presentation.

Significance of the Achievements

It is impossible to predict what the user is interested in or what kind of knowledge she has. This system therefore allows the user to interact with the system during the presentation, which changes the rest of the presentation, so that the presentation adapts to the user on the fly. Owing to this functionality, the user is able to efficiently access the parts of huge content which interest her. This will promote various sorts of communication and technology transfer.

Technical Developments

We have developed Multimodal Common Format (MMCF), which is a method for describing the semantic structure of multimodal content on the basis of a method for describing the semantic structure of linguistic content. This presentation system performs presentation using multimodal content structuralized with MMCF and interacting with the user in accordance with the semantic structure. The content can be summarized by evaluating the importance of each part of it according to the semantic structure, but this summary is not in general adapted to the interest or the knowledge of an individual user. We the presentation must dynamically change based on an investigation of what each user is interested in. Our system collects information on the user by interacting with her in line with the semantic structure. Namely, the user can add nodes to the presented network, change the importance of nodes in the network, and so on, to inform the system what she wants to know at the moment. The system alters the importance of each part of the network, resulting in changes in the presentation.

Such an interactive presentation has been impossible so far without a human presenter. The flexibility of a human presenter is based on her semantic understanding of the content. Our system realizes part of this flexibility by using semantically structured content.

Demonstration

We demonstrate how the presentation changes in response to interactions, adapting itself to each individual user. You can also experience an interactive presentation yourself to feel the potential of this technology.

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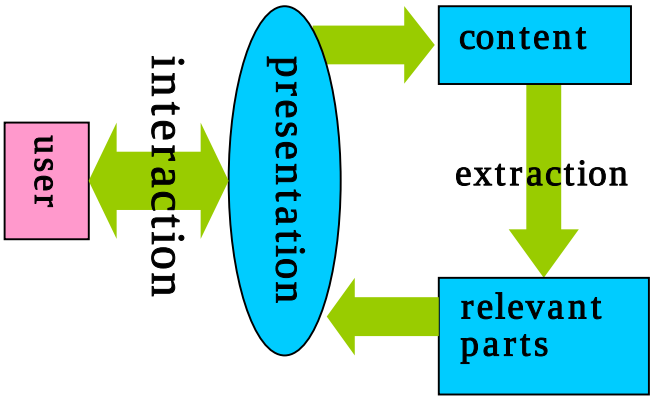


CrossMediator

Construction of CrossMediator

Information-bases Functions TRC Laboratory

Description of the Achievements

We have developed a system called the CrossMediator which realizes a complex of retrieval systems which works among multi-media databases composing of still image, motion image, speech and text. The main body of the CrossMediator consists of retrieval engines and methods to obtain well-coded and well-organized databases. This paper shows two retrieval engines which have been developed for realizing realtime video and speech retrieval and a word set extraction from an unknown query still image to access the Internet.

Significance of the Achievements

Human access to WWW information has to become media-independent to permit full access to content. For instance, we need to have an image as a possible query in order to retrieve text, or a speech utterance as a query in order to retrieve motion image.

So fare, relatively very limited parts of such functionality are feasible, based on symbolic representation and from the results of pattern recognition. For instance, image understanding produces symbolic representation which becomes a set of keywords to retrieve a text. However this type of classical paradigm is not applicable to real world data. In the real world, objects are not segmented in advance, nor is it feasible to assume a very large number of concept categories, nor also can we avoid the all-pervasive presence of irregular noise which is hard.

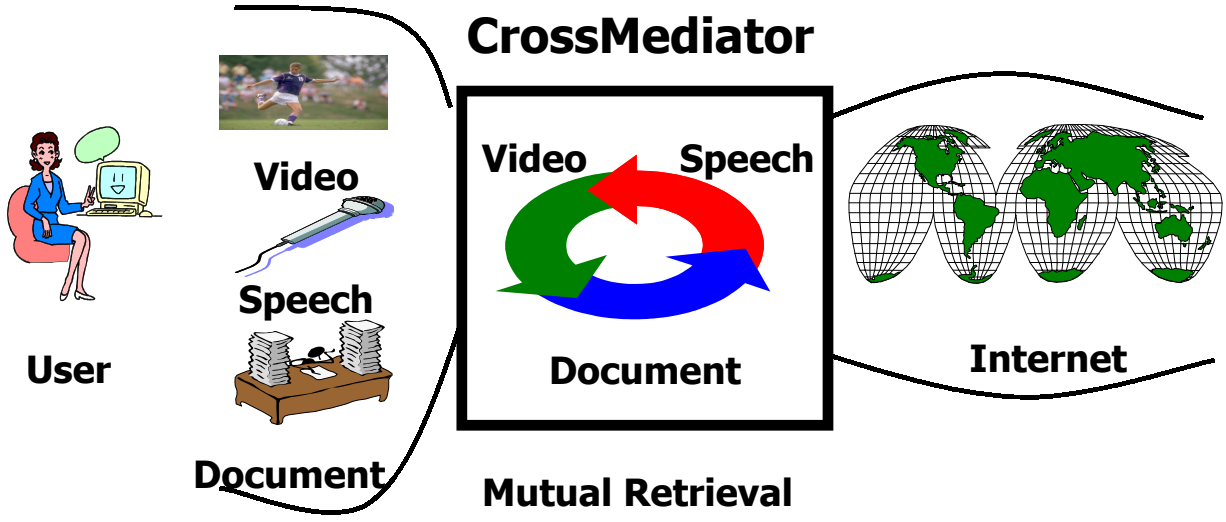
Technical Developments

We have developed many methods including Rutic, Aisic,Fast CDP, Mp-CDP, s-CDP, RIFAS, IRIFCDP, Galaxy Clustering which seem very promising for resolving main problems of the CrossMediator.

Demonstration

The list of the demonstration is as follows;

1. Realtime Video Retrieval
2. Bi-directional Search System for Image and Words
3. Speech/Text Retrieval by Speech
4. Speech to Video Retrieval by Speech
5. Music Retrieval System by Humming
6. Audio Scene Retrieval
7. Realtime and Automatic Topic Segmentation of Speech
8. Text Retrieval with Keyword Association
9. CrossMediator on PDA Terminal
10. Genetic Information Retrieval Syetem
11. CrossMediator on PDA Terminal
12. Realization of CrossMediator on PC Cluster
13. CrossMediator for Video Ver.2



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CITY-TRAFFIC

Reflective Teams

Theoretical Foundation GMD Laboratory

Description of the Achievements

The core of CITY-TRAFFIC is a highly detailed agent-based micro-model of traffic in high-density urban areas. CITY-TRAFFIC is a prototype **Artificial Reality** system. It is a hybrid of sensor-supported traffic monitoring systems, which run in real-time, and a micro-simulation using real traffic data. CITY-TRAFFIC has been implemented with the **Flip-Tick Architecture**, which has been developed to ease the implementation of Artificial Reality systems.

Significance of the Achievements

Traffic control and information systems are increasingly used to regulate traffic in large cities. Telematics offers new solutions for better mobility and safety while reducing the impact on the environment. CITY-TRAFFIC is based on the combination of various technologies for collecting, processing, and simulation of traffic data. It is part of a traffic management system. It is totally based on micro-simulations. Previous systems used very artificial macro-simulations of traffic flow because of performance constraints. CITY-TRAFFIC will be used by individual users to obtain traffic information and traffic dependent optimal routes. It supports various forms of public transport and city planning authorities.

Technical Developments

In many areas of software technology there has recently been a marked shift from centralised to decentralised modelling. Agent-based systems currently represent the most sophisticated level of this development. These large software systems consist not simply of a single central program but of many autonomous program agents co-operating with each other. In order to allow an efficient large-scale simulation of more than 100.000 agents, a specialized software, called Flip-Tick Architecture (FTA) has been developed by GMD. The FTA cluster operating system allows an efficient use of powerful PC cluster hardware at low cost. By simulating concurrently hundreds of thousands of software agents, CITY-TRAFFIC offers the unique possibility of creating a comprehensive, true to scale and function, real-time electronic picture of actual traffic movements in a given region. These features define an **Artificial Reality (AR)** system.

The first prototype of CITY-TRAFFIC has been developed for the city of Bonn. All main traffic junctions are monitored by sensors which transmit traffic flow information to a central computer. With the help of AR technology CITY-TRAFFIC uses this data to simulate individual vehicles in numbers typical for Bonn. The geometry of the actual roads, e.g. the length of turning lanes, and position and function of the sensors, are exactly matched by the simulation. In addition, the switching behaviour of the traffic light systems is also realistically simulated, including elements such as public transport vehicle priorities.

All relevant traffic data are recorded and processed by an integrated system. The information covers a variety of categories, from the geometry of traffic junctions and the control programs of traffic light systems to current traffic flows. These static and dynamic forms of data are recorded in the AR database, and the resulting AR model of a town forms a perfect basis for town and traffic planning.

CITY-TRAFFIC will be used by the City of Bonn when the whole area of Bonn (63 km²) has been input (End of 2003).

Demonstration

The demonstration will be related to an area, called the “city ring” of Bonn. We will show the application of CITY-TRAFFIC for the following typical problems:

“What is the current traffic situation?”

The AR database documents the spatial distribution and flow of traffic on the city ring. Effective traffic planning can then be based on information extracted from it.

“What traffic problems are developing and what is causing them?”

Traffic incidents can be accurately reproduced in Artificial Reality subsequently analyzed.

“What are the effects of a change in the road network?

Lanes can be allocated differently, one-way roads might be introduced. CITY-TRAFFIC can be used to analyze the effects of these changes and even optimize the traffic flow on a given road network.

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Stochastic Pattern Computing

Indexing and retrieval of text using Stochastic Pattern Computing

Theoretical Foundation SICS Laboratory

Description of the Achievements

How does the **brain** compute? Can we build a **computer** that acts the same way? These are our underlying research questions.
Think of a good librarian. Then think of a retrieval system. How can we make the system behave more like the librarian? What is missing? Understanding **human data** the way **humans** do! To do this we need to make a system learn and represent knowledge in some human-like way.
Our demonstrator shows a retrieval system and also shows how can we retrieve texts in a language we do not know well. This is done by training the system on large amounts of textual data, so that the system can represent the meaning of words based on their usage in text.

Significance of the Achievements

The next generation of systems needs to

- communicate well with people
- behave more like people
- find and collect information
- create information from data

and to do this, a system **must** be able to model **human data** the same or similar way **humans** do. The system must be able to detect analogy, not be overwhelmed by new data, be flexible in both learning and application of data.
We have developed an approach which behaves reasonably in our example application: our example application uses a model of text understanding based on real-world human language use.

Our results are for designers and builders of next-generation information processing systems: they do not need to be exclusively applied to information retrieval.

Technical Developments

Holistic Representation and Stochastic Computing combine to provide robust, realistic, scalable, and ultimately useful algorithms, as demonstrated by example application.

Demonstration

Our demonstration will show how Stochastic Pattern Computing can be applied to the text retrieval domain. One demonstration system will retrieve texts from an example database; another will help users formulate multi-lingual queries by suggesting translations of search terms.

Our system is trained on large amounts of textual data in several languages. The system extracts correspondences between words through their occurrences in text, and builds up relations between words that occur in similar contexts – even across languages!

The first demonstration shows how a retrieval system can be built on the basis of word relationships.

The second demonstration system shows how the system can aid a user formulating a query: the user enters a word and the system suggests synonyms or near-synonyms for it, thus adding information to a query.

We expect this to be especially useful in multi-lingual use, where the system will provide translations of the word, giving the most similar words as found in the training texts. Formulating a useful query in a language one does not know well is difficult, even if the user in question can read the retrieved text with little problem. This application is intended to provide help for that situation.

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Learning and Information Integration

Learning and Information Integration

Learning and Integration Lab, RWI-Center, AIST

Description of the Achievements

Establish learning and inference technologies using graphical models, probability distribution models with combinatorial graph structure, such as Bayesian networks, probabilistic constraint program, multivariate models, mixture models, and genetic algorithms.

Significance of the Achievements

- Enabling learning and integration of real-world information by efficient learning and inference algorithms
- Investigate complex learning process of graphical models and clarify special features.
- Novel schemes of learning suited for real-world intelligent systems are given.

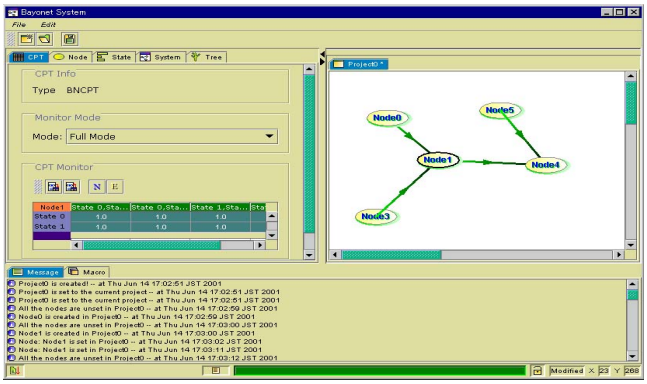
Technical Developments

- Efficient learning and inference algorithms based on properties of each model.
- .Packaging into user-friendly software
- Introduce interaction between learning systems and humans into learning processes.

Demonstration

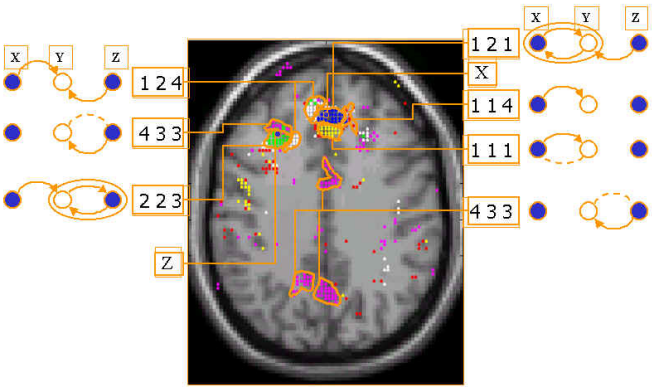
Two major results, Bayesian network construction tool BAYONET, and multi-variate information analysis system are demonstrated.

Bayesian network is a graphical probability model which represents conditional independence between random variables using directed acyclic graph and realizes efficient learning and inference using the independence. It is considered as one of the most prominent tools to deal with complex real-world information. We propose to use neural network to approximate conditional probabilities and develop a



software tool to support construction of Bayesian network using data in data bases. The system is implemented in Java and has elegant graphical user interface.

Multivariate information analysis is a method to extract relationship between random variables based on analyzing the structure of mutual information between random variables. We implemented a software tool to apply the method to analyzing fMRI brain image data.



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Neural Networks as Symbols

Symbol Pattern Integration

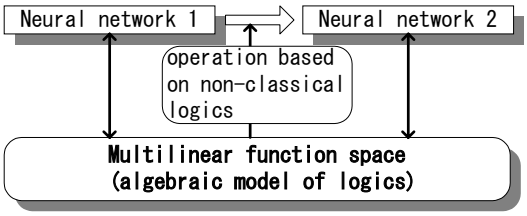
Theoretical Foundation Toshiba Laboratory

Description of the Achievements

We established logical reasoning method of neural networks. Traditional connectionism aims for translating logics based on symbols into neural network architecture. On the other hand, our approach makes it possible to treat neural networks as same as propositions in logics, which supports the base of symbols pattern integration.

The logical reasoning of neural networks represent pattern data which are difficult to represent as symbols, because neural networks have ability to approximate patterns by learning.

In our approach, each neural network is translated to a "logical vector" in multilinear function space, and logical reasoning is realized as the operation based on non-classical logics.



Significance of the Achievements

A new method for integrating connectionism and symbolism is suggested.

Our method can be applied to "pattern reasoning". Pattern reasoning is realized by logical reasoning of neural networks which approximate patterns after learning. This method enables to avoid the knowledge acquisition bottleneck caused by translating patterns into symbols in the traditional artificial intelligence.

Theoretical framework for pattern reasoning is established. Further research is necessary to apply our method to practical pattern data such as images and time series in various fields.

Technical Developments

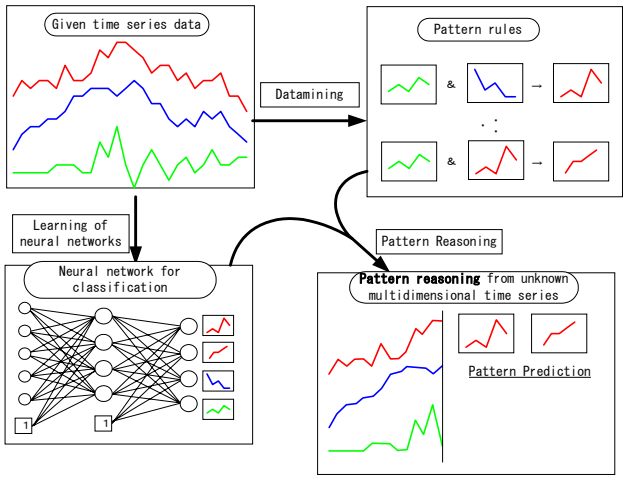
Two main theorems for logical reasoning of neural networks are proved. The first one is that multilinear function space is algebraic model, and the second is that neural networks are multilinear functions. We can treat both neural networks and propositions in the same framework mathematically based on these theorems.

In order to realize the logical reasoning of neural networks, mathematical operators based on non-classical logics are defined. And new methods of neural network learning that make pattern reasoning more precise, is realized.

Demonstration

Outlines of logical reasoning of neural networks, and application for pattern reasoning are introduced.

We applied pattern reasoning to prediction of financial data.



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Distributed and Active Learning

Scalable Learning methods and their applications to genetic and natural language information processing

Theoretical NEC Laboratory

Description of the Achievements

We have developed a theory of "active and distributed learning" as a new fundamental theory for machine learning. This theory consists of three methods: 1) *distributed learning* -a method for unifying learning results obtained by a number of distributed learners to get a better learning result 2) *active learning* -a method for selecting training examples in order to learn from a smaller number of examples, and 3) *knowledge evaluation* -a method for qualifying the learned knowledge on the basis of information criteria and exploration-exploitation trade-off. We demonstrate the effectiveness of this theory through its applications to natural language processing and genetic information processing.

Significance of the Achievements

Our theory provides strategies for designing machine learning algorithms attaining high scalability, high efficiency both in sample and time complexity, and robustness.

For example, as an application of our theory to natural language processing, we developed a word clustering algorithm on the basis of MDL(Minimum Description Length) principle and achieved highest rate(90%) of disambiguation to date(the latest best record was 82%). This result is expected to contribute to drastically increasing the accuracy of machine translation.

Further, as an application of our theory to genetic information processing, we developed a strategy for experimental design for identifying MHC binding peptides on the basis of committee-based active learning using selective sampling. It drastically reduced the number of experiments for identifying the peptides from at most 20^9 to approximately 10^3 .

Technical Developments

As a method of distributed learning, we proposed *Distributed Cooperative Bayesian Learning Strategies (DCBs)*, which provide a strategy for learning from distributed information sources. DCBs work as well as the non-distributed learning strategy in the sense of prediction accuracy, while achieving significant speed-up in computation time.

As a method of active learning, we proposed *committee-based active learning strategies* using *selective sampling*. In their applications to drug-design, they successfully select a significantly small number of informative experiments from a numerous number of experiments.

As an method of knowledge evaluation, we proposed a framework called a *Lob-Pass Problem*, in which we consider the exploration-exploitation trade-off and design an optimal strategy for performing knowledge acquisition and knowledge utilization.

Further we developed a word clustering algorithm on the basis of the MDL principle with its applications auto thesaurus generation.

Demonstration

1） Cluster ：a word-clustering tool .

It takes as input co-occurrence data of two words and outputs a set of word clusters. Each cluster is obtained based on the MDL principle, and in it words are significantly co-occurred.

2） MDL2： a tool for generalizing slot frames.

It takes as input original thesaurus and co-occurrence data of words and outputs a generalized thesaurus, which is optimally pruned using the MDL principle. Using this thesaurus, we identify a word class related to an input word.

These tools can be applied to disambiguation of words in machine translation.

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Probabilistic Knowledge Representation

Real world applications of Bayesian networks

Theoretical Foundation SNN

Description of the Achievements

Bayesian networks are a novel approach to represent uncertain information. Logical (expert) systems, learning methods (neural networks) and statistical tools can be considered special cases of this general approach. In our RWC research, we have developed novel algorithms for learning and reasoning, using the Bayesian approach.

Significance of the Achievements

The outcome of this research makes large scale probability models computationally feasible for data mining, time series modeling, monitoring and control and expert systems

Technical Developments

- Approximate reasoning methods are based on mean field theory
- The medical diagnostic system is based on a Bayesian network
- The interactive music system is based on switching Kalman filters
- The BayesBuilder graphical software is written in C++ and Java 1.3

Demonstration

Approximate inference

A popular approximation scheme is provided by mean field theory, originally developed in the statistical physics community. The approach attempts to find an approximating, tractable, distribution q that is as close as possible to the original distribution p. The standard approach uses a factorized distribution for q. Our approach extends this into two novel directions. The first extension is the inclusion of structure in the approximating distribution, ie. using a non-factorized distribution q. The second direction is to consider higher order (TAP) approximations.

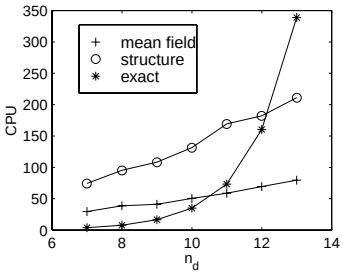

Figure 1:
CPU-time for exact and approximate inference as a function of the network size

Medical diagnosis

The medical diagnostic system is based on a probabilistic model and features inference with missing values and reasoning with multiple causes. The system provides a differential diagnosis, insight in underlying mechanisms and assists the physician in the diagnostic process.

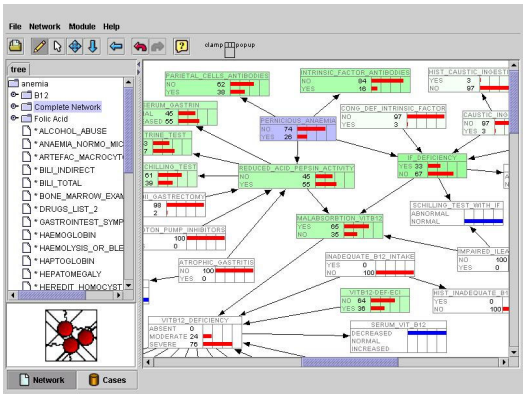

Figure 2: The BayesBuilder software for graphical models

Music transcription

The other application is an automatic music transcriber, which automatically generates an acceptable music score from onsets obtained from a MIDI keyboard. There are two problems in automatic transcription: tracking tempo fluctuations and ``filtering out'' expressive timing deviations. If these fluctuations are not filtered out, the resulting notation would be very complicated and useless. This is a shortcoming of current commercial transcription software. We developed a dynamic Bayesian network which jointly tracks the tempo and quantizes the events. This model closely resembles human performance on this task.

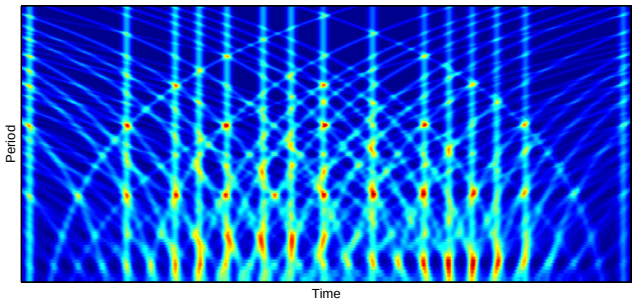

Figure 3: Tempogram representation for tempo tracking

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Office Robot Jijo-2

Learning and Information Integration of Office Robot Jijo-2

Jijo-2 Robot Lab, RWI-Center, AIST

Description of the Achievements

We developed a prototype of office service robot, Jijo-2, which can navigate in real office environment, gather information, and provide information through spoken dialog between office members and visitors.

Significance of the Achievements

- Showing the promising possibility of robot-human communication.
- Open a new technology field, “autonomous learning robots” and “interactive robots”.

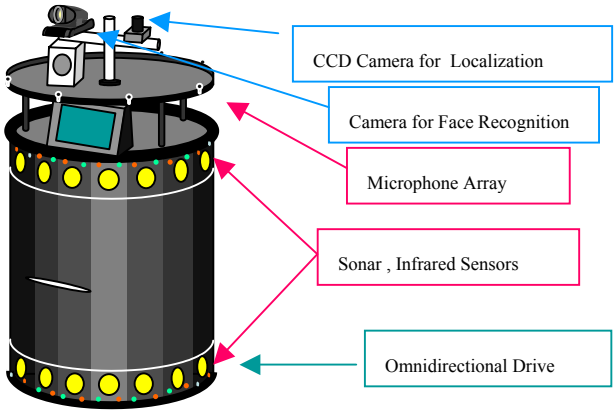
Technical Developments

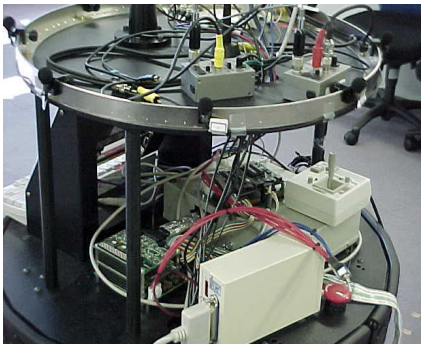
- Establish the technology for autonomous navigation in real environments integrating information from various sensors such as sonar, vision, etc.
- Event-driven multi-agent software architecture to integrate multiple modalities of robot.
- Robust speech recognition and spoken dialog capability using microphone array and flexible dialog control.
- Face recognition which is robust for rotation and scaling of face image.
- Extendable interface to external data-base for providing various information.

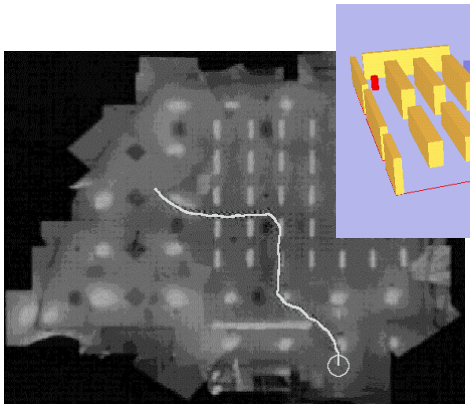
Demonstration

We will demonstrate navigation and dialog capability of Jijo-2 robot. according to visitors requests, the robot navigates in the exivision hall avoiding obstacles and people. During the navigation it localizes itself using visual sensors.

We will integrate face recognition module developed at RWC KRDL Lab. and demonstrate human-robot interaction using the face recognition.







In order to present full performance of Jijo-2 and elemental technologies used in the robot, we will make video presentation also.

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Autonomous Environment Learning

Active Map Building and Sensoric Representation

Autonomous Learning Functions SNN Laboratory

Description of the Achievements

An internal model of the environment is needed to navigate a mobile robot optimally from a current state toward a desired state. Such models can be topological maps, based on labeled representations for objects and their spatial relations, or geometric models such as polygons or occupancy grids in the task space of the robot. Our robot is equipped with a panoramic vision system. Instead of modeling the geometric properties of the environment we model the relation between the images and the robot location directly (*appearance modeling*). In a *learning* stage a database of images and corresponding positions is created. For localization we use a Markov localization procedure, where an estimate of the position of the robot is updated with visual information. The robot is able to traverse long distances. The method is robust to wheel slip, incorrect motion models and can handle the `kidnapped robot' problem. In this approach it is crucial to have good image features because the original images are too high-dimensional for storage. We used Monte-Carlo methods (particle filters) for the representation of the probability distributions.

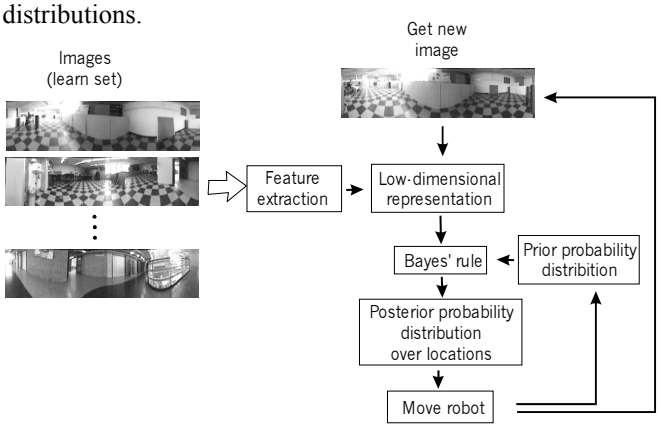

Figure 1: schematic representation of our localization method.

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Significance of the Achievements

The localization methods we have developed are important for a new development in robotics: the service robots in ambient intelligent environments. We foresee that in the near future there will be many robots in human-inhabited environments, such as offices, supermarkets and houses.
Our method enables localization of the mobile robot without any a-priori geometric map. This means that the user can simply train a robot to model the environment by positioning it at various locations. This is a very important feature for personal robots, cleaning robots and other service robots. This type of robot will be of great importance in future ambient intelligent houses and office environments.

Technical Developments

The technologies we have developed for localization:

- Automatic extraction of optimal linear image features
- Probabilistic method to infer the position of the robot
- Robust tracking with the auxiliary particle filter
- Kidnap handling through delta-state filtering

The technologies we have developed for spatial reconstruction:

- Stereo from panoramic images
- Probabilistic stereo range data fusion

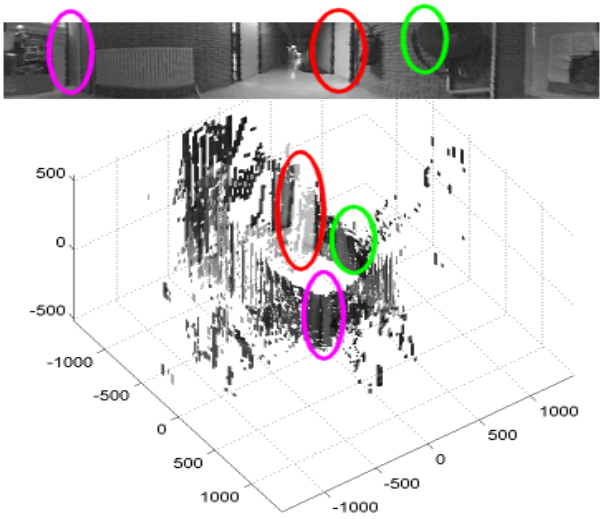

Figure 2: spatial information from four omidirectional images.

Demonstration

We will show the robot which is able to navigate on a map which is learned by the robot itself. We will show the robustness to wheel slip and inaccuracies in in the wheel encoders by `kidnapping' the robot: lifting it and putting it at some unknown location. We will also demonstrate our multi-baseline panoramic stereo algorithm.

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Self-Reconfiguring, Learning Robots

Project DRAGON

Autonomous Learning Functions SICS Laboratory

Description of the Achievements

We have developed a learning method based on "self-awareness," and design principles for real-world heavy-load robots, which support this type of autonomous learning.

Significance of the Achievements

- Showing how autonomous learning of self-repair can utilize special robot design.
- Introducing first heavy-duty autonomous robot joints and connectors supporting faster learning by "self-awareness."

Technical Developments

- Learning is implemented using reinforcement, accelerated by trials in an on-line, real-time self-simulator.
- Determination that the method is easy to implement, but requires fast simulation.
- Derivation of building block requirements, which allow simple kinematics and fast simulation.
- Showing 2-DOF symmetric roll-pitch-roll actuated CV-joints exist, which completely separate the roll and pitch degrees of freedom, and which are optimal for autonomously learning locomotion.
- Showing maximally symmetric, hermaphroditic latching connectors exist, which are self-aligning in 5 DOF, and which are optimal for autonomously learning how to connect.

Demonstration

We present a demonstration where robots connect using the connector and an autonomous learning procedure. We will show and explain the basic joint and connector modules close-up, and test their robustness. Visitors will be allowed to touch and feel the equipment hands-on. We will also illustrate the functionality by a short video.

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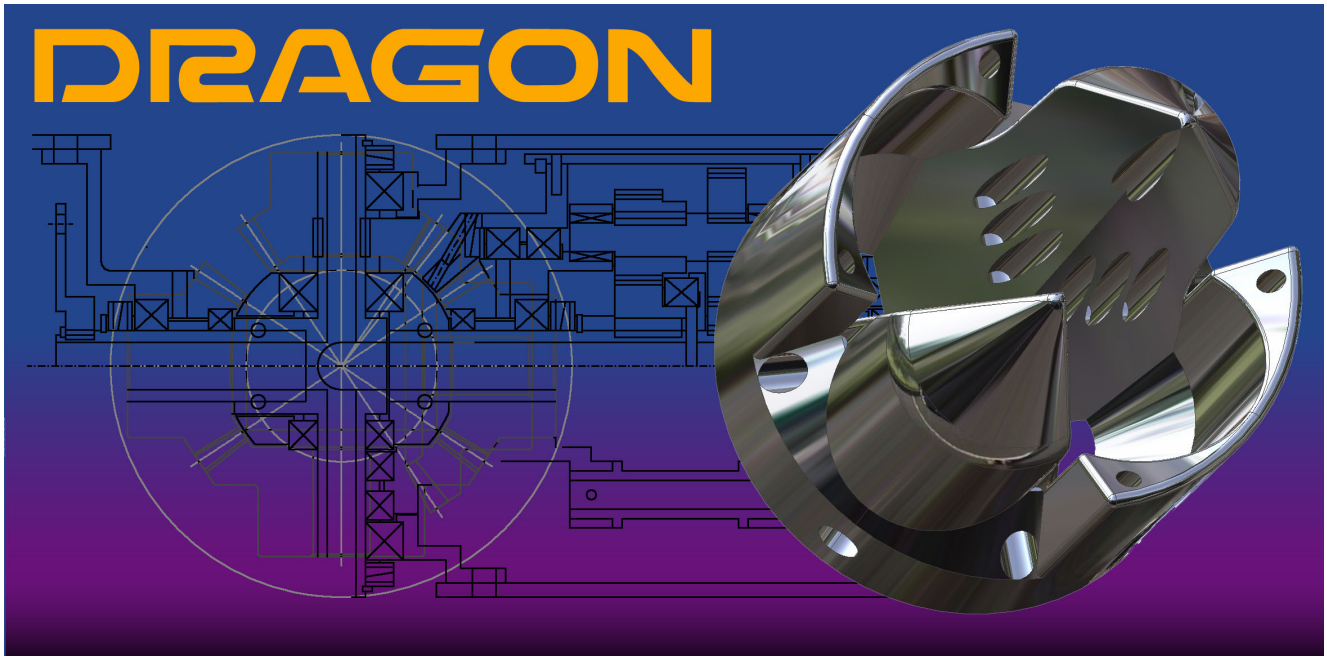


Autonomous Learning Function

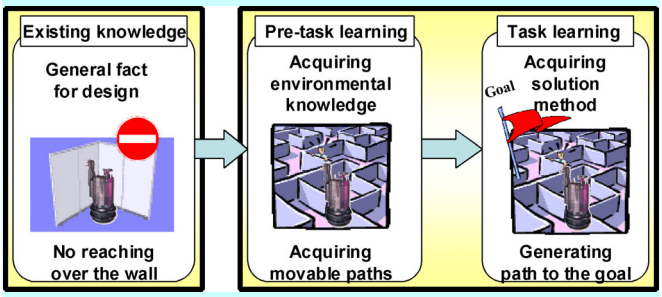
Autonomous learning function on mobile agent

Autonomous Learning Functions Fujitsu Laboratory.

Description of the Achievements

In previous systems that handle information from the actual environment, the system learns tasks using knowledge of the designed environment first obtained by humans. However, the high cost of designing systems that obtain knowledge from the environment becomes a problem.

We propose a system that automatically obtains knowledge of the environment prior to task learning: an autonomous learning framework. With such a system, the design cost associated with obtaining knowledge about the environment within which the system functions can be dramatically reduced.



Significance of the Achievements

As a technique for obtaining the requisite knowledge, we developed a "matchable situation decomposition method" that automatically extracts closely related, repeating items of partial information related to the environment. This information is considered to be very effective for task learning. Using combinations of this partial environmental knowledge obtained with this method, the costs associated with learning can be reduced, and the applicability of the system will expand rapidly because generic capability can be established with less experience.

Technical Developments

The "matchable situation decomposition method" has a central role in the pre-task learning process. In this method, a set of partial environmental knowledge items that have internal consistency are selected by simultaneously choosing them based on the volume of features and events matched against formatted data in a spreadsheet. To select partial environmental knowledge, evaluation criteria are used based on "maximizing matching opportunities."

In addition, distributed intelligence architecture (CITTA) was developed to combine and utilize the partial environmental knowledge obtained in pre-task learning.

Demonstration

The results of the status parsing method can be demonstrated using a door and key problem. An agent placed in a particular environment is able to receive sensor information such as positioning information, the existence or absence of a key or a door, and is able to move to the four directions (left right, forward or backward).

In autonomous learning, the partial environmental knowledge such as the relation between the key and door and the relation between a position and movement were acquired in pre-task learning phase.

In the goal seeking task learning phase, quantity of an experience required for the action determination is reduced, by using partial environmental knowledge. For this reason, this system can generate the path plans for the goal which includes action sequence for taking a key if necessary, by few

Environment Information

	position	property	ornament	action
time1	position1	key	door	↑
time2	position2	no	door	↓
time3	position3	tel	door	→
...	...	...	...	...

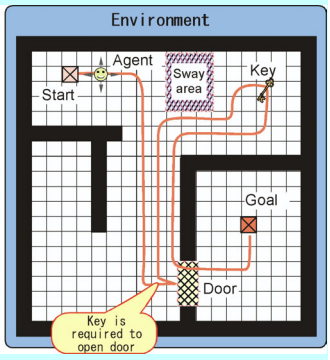


Figure 2. Door & Key task using part environment knowledge

experiences.

Moreover, in autonomous learning, the experiences during task learning are decomposed according to the partial environmental knowledge. This system can respond to new environment quickly by combining a partial experience obtained in former task learning phase.

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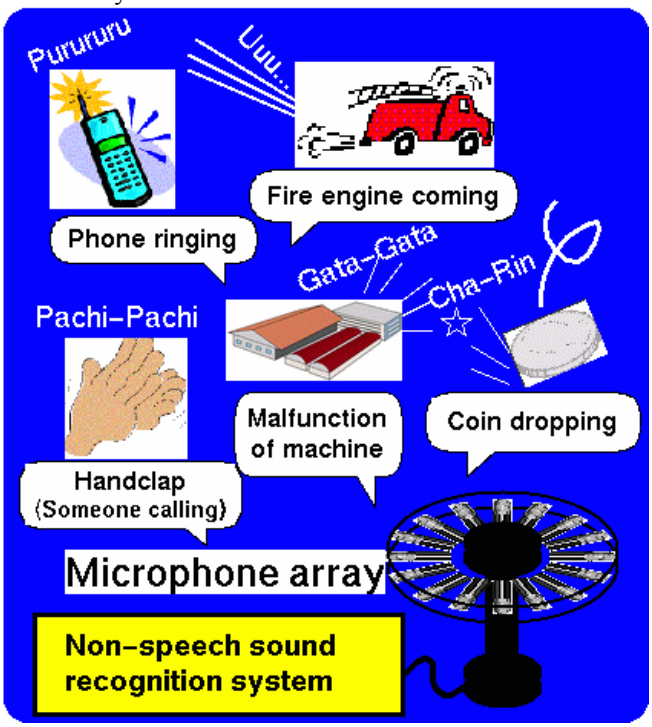
Non-Speech Sound Recognition System

Sound Scene Understanding in Real Acoustical Environments

Autonomous Learning Functions MRI Laboratory

Description of the Achievements

"Non-speech Sound Recognition System" recognize various sounds other than human voice in real acoustical environments It recognize non-speech sounds registered in advance and detects its direction and type of sound source under noisy environment.



Significance of the Achievements

The function of hearing non-speech sounds can add value to various devices. For example;

- Detecting malfunction of equipment in factories by hearing abnormal sounds.
- Vehicles for hearing-impaired can hear warning horn or siren of ambulance
- Surveillance camera turns toward sounds
- Autonomous robots can respond to someone's hand clap or whistle
- Detecting baby's crying at nursery or home

Technical Developments

Beam-former technology

It can extracts sound wave from specific direction using microphone array that has many microphones. It can focus on omni-direction simultaneously and in parallel unlike directional microphone.

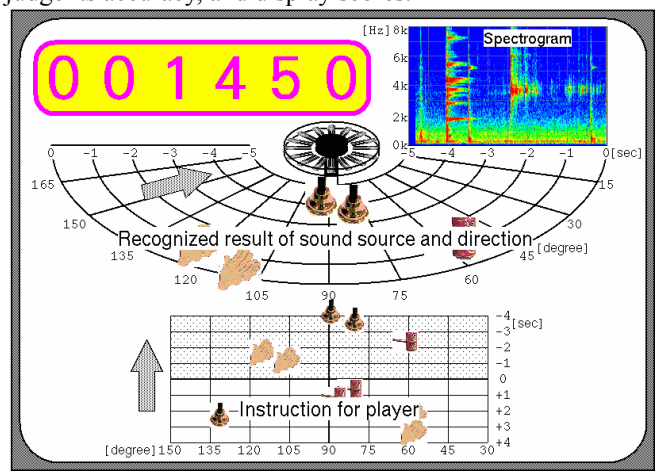
Non-speech sound recognition technology

It can recognize various non-speech sounds fast and accurately by means of multiple matching method for single impulsive, intermittent, and continuous sounds.

Demonstration

Sound game

It is a video game how accurately player make sounds. "Source", "direction", and "rhythm" of sounds are instructed on the screen. The computer recognizes player's sounds, judge its accuracy, and display scores.



Small acoustical diagnosis system

We implement beamformer and non-speech sound recognizer into a small embedded device. It works as an internet server and as ubiquitous sensor. It is based on PowerPC G3 350MHz processor card and consists of 100Base-T LAN, 8ch filter amplifier, and 8ch A/D converter. It is all-in-one acoustical diagnosis server.

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Optical Neural Network

Evaluation of Massively Parallel and High Capacity Computing Systems

Information Optics Lab, RWI-Center, AIST

Description of the Achievements

We developed a high-speed image processing system that controls machine moving with neural network learning. The operation speed is quicker than conventional system constructed by a camera and a computer.
The parallel opto-electronic devices and unconventional optics compose this system. The key opto-electronic device is Digital Smart Pixel (DSP) that developed in the RWC. It became possible that most processing was executed in parallel using the parallel information transmission by light and parallel opt-electronic devices.
Moreover, a special program shouldn't be necessary by implementing a neural network on this system, and flexible information processing was realized in the environment.

Significance of the Achievements

With conventional image processing systems composed of cameras and computers, two-dimensional images are converted into the time-series electric signals, and transmitted to the computer. It is difficult to get enough speed because of this bottle bottleneck with usual systems. The system, which used parallel opto-electronic devices, performs high-speed operations by parallel information processing/transmission and sending only necessary information to the computer. It can be applied in the robot and the FA fields, which need high-speed control and feedback of ms order.
And, realization in the large territory is expected from flexible processing being realized without complex programs by implementing a neural network on this system.

Technical Developments

The simple processor unit which has the input and output ports (photo diode + LED) of the light is made a pixel and the pixels are aligned in two-dimensional in DSP that was developed in the RWC project.

A system was constructed by DSP as the key device, parallel two-dimensional opto-electronic devices and new optical elements such as lens arrays. The optics reproduces of the images, multiply and local accumulate using the light. Subtractions, non-linear functions and memory are done with electronic circuits.
The neural network, which had a learning capability, was realized on this system. Vector-matrix multiplications in the neural network operation are done in optics in the system, and non-linear function and so on is being carried out with electronic circuits. A high performance is realized by the combination of each territory of the light and the electron.

Demonstration

Target tracking is executed by using the optical neural network. The neural network starts from the conditions that nothing is being learned in the beginning. The system learns and become running after the target according to the teaching signals that are obtained by an operator. Finally, the system can track the target with the high-speed that the operator, or the usual system which uses a camera and a computer, can’t run.
Used DSP of 8x8 pixels performs the hidden layer of 32 neurons. The inputs of DSP are obtained by analogue intensities of light and outputs uses the digital output of the bit. Input was 256 neurons with 16x16 pixels, and realized the neural network structure of 3 layers.
High-speed of the system, which used parallel, opto-electronic devices and a learning function by the neural network are confirmed by the demonstration.

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Digital Smart Pixel Array

Digital Smart Pixel Array and Optical Assembly

Adaptive Devices Matsushita Laboratory

Description of the Achievements

We have developed a high-speed image-processing sensor, the Digital Smart Pixel Array, which consists of an array of pixels with “eye”, “ear”, “brain”, and “mouth”.

Because conventional image sensors have only one output port, detected 2-dimensional data by them has to be transformed into serial data before the data can be output. This restricts the processing speed available for image processing with such an image sensor, which is usually more than 33 ms/frame. This represents the bottleneck in conventional image processing systems. In order to remove this bottleneck, each pixel in our Digital Smart Pixel Array has an “eye” for sensing the images, an “ear” for receiving information from the neighboring pixels, a “brain” for data processing and a “mouth” for data transmission to outside of the device. These functions incorporated on all of the pixels realise high-speed parallel processing.

The fabricated devices include a total of 16×16 pixels, and consist of a DPE array (Digital Processing Element array), discrete LED’s and optical element arrays. The DPE array is an LSI, and incorporates arithmetic logic units and photo detectors. The LED’s and the optical element array are assembled on the DPE array. We have also developed an image parallel processing system, in which the Digital Smart Pixel Arrays are optically connected.

Significance of the Achievements

The Digital Smart Pixel Arrays remove the bottleneck in the conventional image processing system, and allow us to realise an image-processing speed of under 1 ms/frame, which is over 30 times faster than systems with conventional image sensors. Real-time feedback controlled systems can be easily constructed using the Digital Smart Pixel Array. These inherent advantages of the Digital Smart Pixel Array system should be stimulus for the creation of advanced algorithms and architectures for image processing and machine system controls.

Technical Developments

Precise assembly, in which 256 LED’s are placed onto the exact positions required without any failures, is an essential technology for the high performance operation of the device. We have realised the required precision of assembly by using a silicon substrate with arrayed through holes, which can hold the LED’s in the exact relative positions.

The Digital Smart Pixel Array simultaneously processes data at each pixel under the control of external instruction streams. Previous vision sensors were special purpose devices with usually only a few processing functions. On the other hand, the Digital Smart Pixel Array is a multi-purpose device, because it can achieve various tasks if we install optimized instruction streams.

The Digital Smart Pixel Array can simultaneously output optical signals corresponding to processing results from each individual pixel. The optical element array assembled on the DPE array has lenses and deflectors, which bring high transmission efficiency to optical cascading systems between the devices. Using this ability to transmit parallel data, processing capability of the Digital Smart Pixel Array system can be expanded.

Demonstration

We constructed a goalkeeping system for use in the game of Air-Hockey in order to demonstrate the advantages of high-speed image processing, multi-stage processing and active sensing, which are made possible by the features of the Digital Smart Pixel Array. The core of this system is the real time image processing system, consisting of digital smart pixel arrays and a PSD (Position Sensing Device) in an optical interconnection. The observation direction of the real time image processing system is constantly shifting, and is trained on the appropriate position on the Air-Hockey game field by using a high-speed rotating mirror. Though this process it can find and track a puck moving at more than 20 km/h. The tracking information that is output from the real time image processing system is fed back in real time control to the movement of the goalkeeper’s arm, which can then defend the goal from shots. Conventional image processing systems cannot follow the high-speed movement of puck because of their low processing speed. This system is the first actual working system that uses optical parallel processing.

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Evolvable Hardware

Evolvable Systems

Evolvable Systems Lab, RWI-Center, AIST

Description of the Achievements

This laboratory focuses on the development of evolvable hardware and evolvable systems using adaptive devices. Evolvable hardware and systems can change their own hardware structure autonomously by the use of genetic algorithms. Some of their applications is very close to industrial usage. The following demonstrations will be shown at the symposium site.

1. Data compression for printing data

This data compression will be the two ISOs (SC29 and TC130) within one or two years. The demonstration of On-Demand-Publishing and the demonstration of on-line distribution of maps will be shown.

2. Analog Evolvable LSI

Intermediate Frequency Filter LSI based on the analog hardware evolution will be commercialized this autumn in cellular phones in Japan.

3. Electromyograph prosthetic hand

The evolvable chip can learn individual differences of electromyography very quicky. The rehabilitation time can be reduce from one month to a few minutes due to this chip.

4. Autonomous Mobile Robot Evolver

The control circuit of moving robot is implemented on evolvable hardware. That allows the robot to adapt the change in the environment. Even if the sensor is broken, the control circuit is autonomously changed and other functioning sensor is used.

5. Evolvable Femto-second laser system

Femto-seconf lasers require very subtle adjustment of positions of optical elements. It usually take 5days.
Evolvable Femto-second laser can adjust positions autonomously in a short time.

6. Evolvable fiber alignment

The alignment of optical fibers requires the precision of micron-meter. The system can do it autonomously.

Significance of the Achievements

The applications of artificial intelligence for industrial use are limited so far. However, the applications of evolvable hardware and systems include hi-end industrial products.

Technical Developments

1. Data compression for printing data

Prediction function implemented on evolvable hardware is the key to the very high data compression rate.

2. Analog Evolvable LSI

By the use of analog hardware evolution technique, high yield rate(97%), circuit space reduction(60% less) and low power consumption(40% less) are realized.

3. Electromyograph prosthetic hand

Evolvable chip can dynamically and flexibly implement pattern recognition circuit tailored to each amputee person.

4. Autonomous Mobile Robot Evolver

High degree of robustness and autonomousness can be obtained by the use of evolvable hardware.

5. Evolvable Femto-second laser system

The evolvable approach made it possible the down-sizing and autoadjustment of femto-second laser systems.

6. Evolvable fiber alignment

Evolvable fiber alignment will realize the mass-production optical devices. Currently, experienced technitians are dedicated to the production.

Demonstrations

In addition to above 6 demonstrations, navigation system for blind people is also shown.

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Reconfigurable Adaptive Device

ALU Based Reconfigurable Hardware: RHW

Adaptive Devices NEC Laboratory

Description of the Achievements

- A programmable hardware called RHW (Reconfigurable HardWare) that significantly enhanced arithmetic operation performance compared with a conventional programmable device FPGA (Field Programmable Gate Array).
- A general purpose accelerator equipped with RHW that reconfigures its hardware structure according to the characteristics of application programs to achieve from 10 through 100 times faster performance compared with conventional microprocessors.
- C language based programming environment for the general purpose accelerator.

Significance of the Achievements

- A general purpose accelerator system has both hard-wired high performance and software flexibility.
- Equipped with just the only one general purpose accelerator, various application areas can be covered. Efficient hardware utilization is also possible by time-division multiplexing of sub processes in an application program.

Technical Developments

- An programmable hardware called RHW as a key device for a general purpose accelerator system. We achieved about two to four times higher integration density of arithmetic operation units compared with a conventional programmable hardware FPGA.
- The general purpose accelerator work in cooperation with a host PC/WS. We developed hierarchical memory architecture and memory control scheme to hide the overhead that causes data transfer between host PC/WS and an accelerator board.
- Hardware synthesis tools and automatic placement/routing tools that takes advantage of the RHW architecture and generates RHW configuration data in less than five minutes.

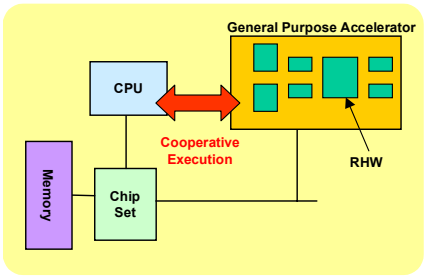
Demonstration

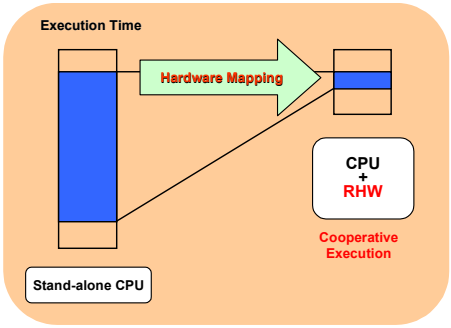
(1) High speed image retreival system on the general purpose accelerator: The system shows ten times faster performance compared with PentiumIII (1GHz). In that demonstration, the accelerator searches a huge number of images and categorizes them. We will show the extremely high performance of the general purpose accelerator by demonstrating both stand-alone PC system and the general purpose accelerator system.

(2) Image recognition system on the general purpose accelerator: The system shows quick time-division reconfiguration on a single RHW chip. The switching time is less than 1/10000 [sec], that makes it possible to change RHW configuration during video rate (1/30[sec]). In this demonstration, pre-process and recognition process are multiplexed and applied to a captured movie.

(3) Programming environment: That demonstrates compilation processes from some applications written in C language into configuration data for RHW.

(4) RHW3: The chip has from two to four times higher integration density compared with conventional FPGAs.





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