IDIAP COMMUNICATION

IDIAP

Martigny - Valais - Suisse

Activity Report 1995

IDIAP–Com 96-01

May 96

Dalle Molle Institute for Perceptive Artificial Intelligence • P.O.Box 592 • Martigny • Valais • Switzerland

phone +41 – 27 – 721 77 11
fax +41 – 27 – 721 77 12
e-mail secretariat@idiap.ch
internet http://www.idiap.ch

Foreword

The Dalle Molle Institute for Perceptive Artificial Intelligence (IDIAP) was founded in 1991 at the occasion of the 20^{th} anniversary of the Dalle Molle Foundation, originally a foundation focusing on studies in algorithmic linguistics, which became in 1985 *Dalle Molle Foundation for the Quality of Life*. IDIAP research activities are of both theoretical and applied nature. Indeed, the approach used at IDIAP is to focus on a given domain of application and elaborate operational systems while developing adequate studies and fundamental theoretical models, thus providing solid and acknowledged foundations to improve the overall framework of the subject areas. The main activity domain of IDIAP is artificial intelligence and more specifically the study of perception, cognition and pattern analysis, both visual and auditory. IDIAP is active in the formation of researchers and engineers and in industrial collaboration, thus promoting the economic development of the Canton of Valais.

Since its foundation and under the initiative of its director, IDIAP has been active in the fields of artificial neural networks, speech processing, knowledge modelling and computer vision.

Currently active research areas at IDIAP are :

- neural network computation and its application to pattern recognition,
- neural networks implementation in optical hardware,
- automatic continuous speech recognition,
- speaker identification,
- handwriting recognition.

These works are supported by the Swiss National Science Foundation, the Dalle Molle Foundation, the City of Martigny, the Canton of Valais and the Swiss Confederation. Moreover, many projects are part of European research projects (COST, Esprit, etc.).

IDIAP has particularly strong relationships with the Swiss Federal Institute of Technology in Lausanne (EPFL), Geneva University, Neuchâtel University, Fribourg University, Bern University, the Swiss Federal Institute of Technology in Zurich (ETHZ) and Louis Pasteur University (Strasbourg). A convention of collaboration between IDIAP and EPFL is about to be concluded. Besides that, IDIAP welcomes and supervises many students from all over Europe.

In 1995, IDIAP worked under the supervision of a scientific and directing committee consisting of Prof. Giovanni Coray (EPFL), Prof. Jean-Paul Haton (University of Nancy, France), Prof. Christian Pellegrini (Geneva University), and Mr. Jean-Pierre Rausis. The directing committee delegated the management of the daily activities of the institute to an internal committee composed by Drs. Gérard Chollet, Jean-Luc Cochard, Emile Fiesler, Gilbert Maître and Eddy Mayoraz. This transitional situation follows the leaving of the former director, Dr. Daniel Osherson, and shall end when a new director is selected by the directing committee.

At the present time, negotiations are being held between the Canton of Valais, the City of Martigny, EPFL and Geneva University, aiming at the creation of a foundation which will give IDIAP a stronger basis.

The directing committee

Préface

L'Institut Dalle Molle d'Intelligence Artificielle Perceptive (IDIAP) a été fondé en 1991 à l'occasion du vingtième anniversaire de la Fondation Dalle Molle, à l'origine *Fondation pour les études de linguistique algorithmique*, devenue en 1985 *Fondation Dalle Molle pour la qualité de la vie*. L'IDIAP se consacre à des travaux de recherche de nature théorique aussi bien qu'appliquée; la démarche de l'IDIAP est en effet de se concentrer sur un domaine d'application donné et de mettre en œuvre des systèmes opérationnels, tout en développant des études et des modèles théoriques fondamentaux adéquats, donnant ainsi à l'ensemble de ses travaux des fondements à la fois solides et reconnus. Le domaine d'activité prioritaire de l'IDIAP est l'intelligence artificielle et plus particulièrement l'étude de la perception, de la reconnaissance et de l'analyse des formes, tant visuelles qu'auditives. D'autre part l'IDIAP est active dans la formation de chercheurs et d'ingénieurs et dans la collaboration avec l'industrie, participant ainsi au développement économique du Canton du Valais.

Depuis sa fondation et sous l'impulsion de son directeur, l'IDIAP a effectivement avancé dans les domaines des réseaux de neurones, du traitement de la parole, de la modélisation de connaissances et de la vision artificielle.

Au moment de la rédaction du présent rapport, les chercheurs de l'IDIAP se consacraient à des travaux sur les sujets suivants :

- le calcul par réseaux de neurones artificiels et son application à la reconnaissance de formes,
- l'implémentation de réseaux de neurones artificiels et le calcul optique,
- la reconnaissance automatique de la parole continue,
- l'identification du locuteur,
- reconnaissance de l'écrit manuscrit.

Ces travaux bénéficient du support du Fonds National Suisse pour la Recherche Scientifique, de la Fondation Dalle Molle, de la Ville de Martigny, du Canton du Valais et de la Confédération suisse. De plus plusieurs projets s'effectuent dans le cadre et avec le soutien financier de programmes européens de recherche (programmes COST, Esprit, etc.).

L'IDIAP a fait un effort de contact particulier avec les institutions suivantes : l'EPFL, l'Université de Genève, l'Université de Fribourg, l'Université de Neuchâtel, l'Université de Berne, l'EPFZ et l'Université Louis Pasteur (Strasbourg). Une convention de collaboration entre l'IDIAP et l'EPFL est sur le point d'être signée. D'autre part l'IDIAP accueille et supervise de nombreux stagiaires européens.

L'IDIAP a fonctionné pendant l'année 1995 sous la responsabilité d'un comité scientifique et de direction formé des Professeurs Giovanni Coray (EPFL), Jean-Paul Haton (Université de Nancy, France), Christian Pellegrini (Université de Genève) ainsi que de Monsieur Jean-Pierre Rausis. Ce comité de direction a délégué la gestion des activités quotidiennnes de l'institut à un comité interne formé des Docteurs Gérard Chollet, Jean-Luc Cochard, Emile Fiesler, Gilbert Maître et Eddy Mayoraz. Cette situation faisait suite au départ du directeur en place, Dr Daniel Osherson, et dans l'attente de la désignation de son successeur recherché par le comité de direction.

A l'heure actuelle, des pourparlers sont en cours entre l'État du Valais, la Commune de Martigny, l'EPFL et l'Université de Genève en vue de la création d'une fondation qui donnera à l'IDIAP une assise et une personnalité juridique.

Le comité de direction

Vorwort

Das Dalle Molle Institut für Perzeptive Künstliche Intelligenz (IDIAP) wurde im Jahre 1991 gegründet, anläßlich des 20-jährigen Jubiläums der Dalle Molle Stiftung, welche sich ursprünglich mit algorithmischer Linguistik beschäftigte und 1985 zur *Dalle Molle Stiftung für Lebensqualität* umbenannt wurde. IDIAP kombinierte theoretische und angewandte Forschung, indem es beides zugleich betreiben. Hierzu werden theoretische Modelle für eine gegebene Anwendung entwickelt, implementiert und verfeinert, was dem Gesamten ein sowohl solides als auch anerkanntes Fundament sichert. IDIAP betreibt Forschung auf den Gebieten der künstlichen Intelligenz, insbesondere in den Bereichen Wahrnehmung, Erkennung und Analyse von akkustischen und visuellen Mustern. Neben der Forschung trägt IDIAP auch zur Ausbildung von Wissenschaftlern und Ingenieuren bei und fördert durch die Zusammenarbeit mit der Industrie die wirtschaftliche Entwicklung des Kantons Wallis.

Seit seiner Gründung befasste sich das IDIAP unter Einfluß seines Direktors mit künstlichen neuronalen Netzen, Sprachverarbeitung, Wissensmodellierung und Computer Vision.

Derzeitige Forschungsschwerpunkte sind:

- neuronale Netze und ihre Anwendung für Mustererkennung,
- Implementierung neuronaler Netze mit optischen Bauelementen,
- automatisches Erkennen natürlicher Sprache,
- Sprechererkennung,
- Handschrifterkennung.

Die Forschung wird unterstützt von der Nationalen Schweizer Stiftung für Wissenschaftliche Forschung, der Dalle Molle Stiftung, der Stadt Martigny, dem Kanton Wallis und der Schweizerischen Eidgenossenschaft. Die meißten Projekte werden im Rahmen europäischer Forschungsprogramme (COST, ESPRIT, etc.) durchgeführt.

IDIAP pflegt Kontakte unter anderem zu folgenden Institutionen: Eidgenössische Technische Hochschule Lausanne (EPFL), Universität Genf, Universität Freiburg, Universität Neuenburg, Universität Bern, Eidgenössische Technische Hochschule Zürich und Louis Pasteur University (Straßburg). Ein besonderes Abkommen der Zusammenarbeit mit EPFL wird demnächst abgeschlossen. Außerdem betreut IDIAP viele Studenten aus ganz Europa.

Die wissenschaftliche und leitende Verantwortung des IDIAP wurde 1995 von einem Aufsichtsrat ausgeübt, bestehend aus Professor Giovanni Coray (EPFL), Professor Jean-Paul Haton (Universität Nancy, Frankreich), Professor Christian Pellegrini (Universität Genf) und Herr Jean-Pierre Rausis. Die Leitung vor Ort wurde von einem internen Komitee, bestehend aus Dr. Gérard Chollet, Dr. Jean-Luc Cochard, Dr. Emile Fiesler, Dr. Gilbert Maître und Dr. Eddy Mayoraz, übernommen. Diese Struktur wurde nach dem Abgang des ehemaligen Direktors, Dr. Daniel Osherson, eingeführt und verbleibt bis zur Benennung eines neuen Direktors durch den Aufsichtsrat.

Zur Zeit werden zwischen dem Kanton Wallis, der Stadt Martigny, EPFL und der Universität Genf Verhandlungen zur Gründung einer Stiftung durchgeführt, die IDIAP eine solide Basis und eine Rechtsstellung verleihen sollen.

Der Aufsichtsrat

Contents

1 Staff

The staff members currently at IDIAP share the following addresses:

mail: IDIAP — Institut Dalle Molle d'Intelligence Artificielle Perceptive
CP 592
CH–1920 Martigny (VS)
Switzerland

Phone: +41 – 26 – 21 77 11

Fax: +41 – 26 – 21 77 12

Internet: `http://www.idiap.ch`

1.1 Scientific staff in 1995

Mr. Olivier Bornet — engineer
`Olivier.Bornet@idiap.ch`

Mrs. Monique Braulin-Frey — visiting researcher
`Monique.Frey@idiap.ch` — at IDIAP in October 95

Mr. Gilles Caloz — engineer
`Gilles.Caloz@idiap.ch` — arrived at IDIAP in November 95

Dr. Gérard Chollet — researcher, speech group leader until June 1996
`Gerard.Chollet@idiap.ch`

Dr. Jean-Luc Cochard — researcher, speech group leader from July 1996
`Jean-Luc.Cochard@idiap.ch`

Mr. Andrei Constantinescu — researcher, Ph.D. student
`Andrei.Constantinescu@idiap.ch`

Mr. Andrea de Pol — researcher
`Andrea.de.Pol@idiap.ch` — at IDIAP from May to September 95

Dr. Emile Fiesler — researcher, neural network group leader
`Emile.Fiesler@idiap.ch`

Mr. Philippe Froidevaux — researcher
`Froidevaux@idiap.ch` — at IDIAP until September 95

Mr. Dominique Genoud — researcher, Ph.D. student
`Dominique.Genoud@idiap.ch`

Dr. M. Mehdi Homayounpour — researcher
`Mehdi.Homayounpour@idiap.ch` — at IDIAP from August to December 95

Mr. Cédric Jaboulet — engineer
`Cedric.Jaboulet@idiap.ch`

Dr. Philippe Langlais — researcher
`Philippe.Langlais@idiap.ch` — at IDIAP until September 95

Dr. Gilbert Maître — researcher, vision group leader
Gilbert.Maitre@idiap.ch

Dr. Eric Martin — researcher
Eric.Martin@idiap.ch — at IDIAP until September 95

Dr. Eddy Mayoraz — researcher
Eddy.Mayoraz@idiap.ch — at IDIAP from September 95

Mr. Perry Moerland — researcher, Ph.D. student
Perry.Moerland@idiap.ch

Mr. Miguel Moreira — researcher
Miguel.Moreira@idiap.ch — at IDIAP from February 95

Dr. Daniel N. Osherson — director
Daniel.Osherson@idiap.ch — at IDIAP until June 95

Dr. Indu Saxena — researcher
Indu.Saxena@idiap.ch

Mr. Georg Thimm — researcher, Ph.D. student
Georg.Thimm@idiap.ch

Mrs. Murielle Vial — researcher
Murielle.Vial@idiap.ch — at IDIAP from January 95

1.2 Non-scientific staff in 1995

Mrs. Alexandra Bender — annotator
at IDIAP from February to August 95

Mrs. Anne Coquoz — annotator
Anne.Coquoz@idiap.ch — at IDIAP from August 95 to December 95

Mrs. Catherine Delattre-Locher — secretary
Catherine.Delattre@idiap.ch

Mrs. Dilia Dély — annotator
at IDIAP until August 95

Mrs. Sandrine Dély-Schindler — annotator
Sandrine.Dely@idiap.ch — at IDIAP from January to December 95

2 Research activities

2.1 Neural Networks group

2.1.1 Main orientations of the research

Although neural networks have proven their usefulness in a broad range of application domains, their wide-scale acceptance and use is hampered by their user-UNfriendliness. That is, a large amount of expertise and training overhead is required for the selection of their topology and their multitude of learning rule parameters. Another crucial problem is that the intrinsic power of neural networks, which lies in their massive parallelism and distributed nature, is not exploited since they are usually only simulated on (sequential) computers. This exploitation by parallel and distributed hardware implementations, whether in electronics or optics, is restricted by the lack of existing neural network adaptations to hardware requirements. The main advantage of optical systems is that massively parallel computation can be performed, and that the number of processing elements can be scaled without compromising speed appreciably. In realizing the great potential of optical computing, and to exploit the full capabilities of optics by taking advantage of the ultimate speed, the speed of light, optical neural networks are to be developed. Optical neural networks provide a promising alternative to electronic systems in the parallel handling of data, offering up to the order of 10 billion interconnections per optical component (!). Having no crosstalk problems and a very low power consumption are additional benefits of optics as compared to electronics; the capabilities of the latter technology being almost saturated. The promise of optics can only be realized if fully optical modules, building blocks for all-optical neural networks, are developed. The newly developed systems are to be applied to a variety of domains, in particular to pattern recognition.

Hence, the research activities of the Neural Computation group for 1995 concern the following four interlocking parts:

I. Compact User-Friendly Neural Networks

II. Optical Neural Network Design

III. Neural Network Adaptation for Hardware Implementation

IV. Applications

Some of our most important research successes related to the four activities listed above are outlined below. The progress of our research during the calendar year 1995 is best reflected in our publications; please refer to our publication in section 6.

I. Compact User-Friendly Neural Networks

A major research goal of the neural computation group is the development of a novel family of powerful multi-functional neural networks that are both compact and user-friendly. This ambitious research has a strong foundation as it is based on the integration of the potential and latest results of IDIAP's research activities in this area.

Compactness will be obtained by complexity reduction strategies based on sparse connectivity and ontogenic training methods that automatically modify the network during the training process. Parameter reduction is established by careful analysis of the networks' functioning and by exploiting the key aspects of neural networks, namely their capability to learn and self-organize.

These easy to use and yet multipurpose neural networks, with their potential to outperform present-day multilayer networks, will also be extremely compact and therefore very suitable for a wide range of hardware implementations.

For testing our neural networks we are using the large corpus of data available at IDIAP. See for example the section on Application to Pattern Recognition, below.

Some specific research successes in this area are:

- We developed a very easy to use and efficient neural network initialization technique that renders the usual trial-and-error process oblivious by eliminating the initial weight range choice [TF] [TF95b].

- We published our results on eliminating a key parameter of the network's nonlinearity by proving its relationship to learning rate and initial conditions, which simplifies the neural network design process [TMF96].

- We improved the Stuttgart neural network simulator (SNNS), Sesame, and our own neural network simulation software package to handle flexible data structures and our new neural network training techniques.

II. Optical Neural Network Design

We are continuing the development of our unique multilayer optical neural network (ONN), having all-optical recall, which is modular and extendible by adding additional neuron layers [SF95a]. This work is performed in collaboration with the Institute of Microtechnology of the University of Neuchâtel. The challenge of multilayer ONNs is to incorporate not only recall, but 'training' as well. In the optical implementation of neural networks typically performed by incoherent techniques, the representation of negative values is precluded. This necessitated a solution which allows optical methods to implement neural networks efficiently. More precisely, we found that subtraction stage is essential for efficient optical implementations. A novel technique for performing the subtraction has been developed and integrated into our multilayer ONN.

In 1995, we started the first phase of the implementation of our large modular optical multilayer neural network with all-optical recall and optically implemented 70,000 information carrying light beams on which the most important operation, the vector matrix multiplication, has been successfully tested.

III. Neural Network Adaptation for Hardware Implementation

It is foreseen that progress in optics, as well as in analog and digital (VLSI) electronics, will increase demands on the development of dedicated neural networks for hardware implementations. Our goal is therefore to develop adaptations of neural networks for hardware implementations by working in close cooperation with groups active in the hardware developmental aspects of it. In this context we are continuing to closely follow the progress in Optical Neural Network research (described in section II.) by extending our techniques to efficiently train modular optical multilayer neural networks with all-optical forward propagation.

The most important goal from the neural network side is to concentrate our activities on both weight discretization and transfer curve adaptation techniques by improving them in applicability, flexibility, and speed. These new weight discretization and network optimization results will also be applied to complexity reduction and integrated into the Compact User-Friendly Neural Networks research.

More specific, we have refined our techniques for handling a large number of nonstandard activation functions as available in hardware, and these techniques have been successfully integrated in our optical multilayer neural network [MFS] [MFS95].

An informative survey of neural network adaptations for hardware implementation can be found in [MF96].

IV. Applications

The neural network models that we have developed and improved by our research efforts have been successfully applied to various problems including handwritten character recognition and pattern recognition in general, classification problems, and quality control.

In 1995 we have started a collaborative project with GPIL in Martigny on the quality control of wrist watches, from a well-known Swiss watch company, by neural networks. This project is based on

neural pattern recognition of the hands of the wrist watches. The current results show that an efficient and fast solution is possible which offers a maximal performance and requiring a minimal training set.

2.1.2 Research projects

♢ Adaptive Optical Multilayer Neural Networks

Funding Swiss National Science Foundation
Partners Institute of Microtechnology (IMT) of the University of Neuchâtel
Duration October 1995 – September 1997
Principal investigator Dr. Emile Fiesler
Other internal staff Dr. Indu Saxena
Description Optical neural networks provide a very promising alternative to electronic systems in the parallel handling of data, especially since currently electronic systems approach their physical (speed) limits. This is especially important in cases where real-time or massively parallel information processing is desired, such as computer vision and speech recognition. This project involves the design and implementation of a large modular optical multilayer neural network. By using an optical device as non-linearity, a unique all-optical recall is established.

♢ Pattern Recognition by Neural Networks for Quality Control of Watches

Funding Industrial project
Partners GPIL (Gianni Pante Ingenierie du Logiciel)
Duration September 1995 – January 1996 (phase I)
Principal investigator Dr. Emile Fiesler
Other IDIAP staff Mr. Miguel Moreira
Description This project concerns the quality control of Swiss watches by neural networks. The challenge of this project lies in minimizing the number of watch images needed to train the system, in order to optimize the robotized control process, while retaining maximum quality.

2.2 Speech group

2.2.1 Main orientations of the research

The speech group is working on *speech recognition* as usually opposed to *speech synthesis*. Its research activities can be described along three main axes:

- automatic speech recognition (ASR) for continuous speech;
- speaker recognition/verification (SR/SV) over the telephone;
- production of large databases of speech samples (S-DB).

In ASR, our group has three main research topics for which financial support has been received. The first topic that can be considered as fundamental research in computer science, is dealing with the concept of multi-agents systems and its use in the set-up of a continuous speech recognition system. The major benefits expected from this approach are the flexibility in the manipulation of heterogeneous knowledge sources and the possibility of implementing an *event-sensitive resolution strategy*. The second topic is about the discovery of a set of robust stochastic models of speech subunits, that can replace the current phonetic models in the context of developing ASR systems using a flexible vocabulary approach. The third topic is concerning technology transfer, as it aims at the set-up of

interactive voice servers prototypes (IVS) based on currently available technology at IDIAP, namely command words recognition based on phonetic models, and speaker verification algorithms.

In SR/SV, our group is concerned, on one hand, by improving the current algorithms used in this field, and on the other hand, by proposing innovative solutions that combine the results of concurrent and/or complementary strategies. To reach these goals, our researchers can take advantage of an existing in-house large database of speech samples designed especially to address the problem of inter- and intra-speaker variability.

One major auxiliary problem related to ASR and SR/SV research domains is the availability of speech resources. IDIAP has started since 1992 to record speech samples over telephone lines. To perform some manipulation tasks on these data, a set of adequate software packages have been developed. As this recording process is still a currently running activity in collaboration with other research centers in Switzerland or abroad, adaptation and dissemination of our software packages is performed.

2.2.2 Research projects

♢ CAVE – Speaker Verification in Banking and Telecommunication

Official status European project LE 1930, Telematics Program, supported by OFES;
Duration Dec. 1st, 1995 – May 31, 1997;
Partners Dutch PTT Telecom, UBILAB, Vocalis, IDIAP, ENST, KTH (SE), KUN (NL);
Internal staff Jean-Luc Cochard (task manager), Dominique Genoud (researcher), Cédric Jaboulet (research engineer).
Description CAVE addresses one of the key issues in telematics transaction services, namely speaker verification to provide secure transactions.

IDIAP is a technology provider in the project and its involvement will be research oriented. Thus it aims at improving the performance of high security verification technology, as well as at providing procedures and data bases that allow objective tests of speaker verification systems.

♢ M2VTS – Multimodal Verification for Teleservices and Security Applications

Official status European project AC 102, ACTS Program, supported by OFES;
Duration Oct. 1st, 1995 – Sep. 30, 1996;
Partners Matra Communication (F), Cerberus AG (CH), Ibermetica (E), EPFL, Université de Neuchâtel, Université Catholique de Louvain (B), University of Surrey (GB), Renaissance (B), IDIAP, Aristotle University of Thessaloniki (GR), Compagnie Européenne de Télésécurité (F), Universidad Carlos III (E), Banco Bilbao Vizcaya (E), Unidad Tecnica Auxiliar de la Policia (E);
Internal staff Gilbert Maître (researcher);
Description The primary goal of the M2VTS project is to address the issue of secured access to local and centralised services in a multi-media environment. The application envisaged is that of a "network-integrated" messaging system that offers real progress with respect to existing communication means, and in particular to extend the functionalities provided by voice messaging services by adding novel and intelligent functionalities, enabled by automatic verification systems combining multimodal strategies (secured access based on speech, image and other information).

♢ SpeechDat – Spoken language resources dissemination

Official status European project LRE 63 314, Preliminary Action of Telematics Program, supported by OFES,

Duration Jan. 1st – Oct. 31, 1995;

Partners Siemens AG (D), GEC (UK), Jydsk Telefon (DK), Philips (D), CSELT (I), Telefones de Lisboa e Porto (P), Inst. de Engenharia de Systemas e Computadores (P), Vocalis (UK), Dept of Phonetics UCL (UK), LIMSI-CNRS (F), Univ. of Amsterdam (NL), SPEX (NL), Univ. Autonoma de Barcelona (S), Univ. Muenchen (D), Univ. of Aalborg (DK), Institut de la Communication Parlée – INPG (F), Defence Research Agency (UK), IDIAP (CH).

Internal staff Dan Andrei Constantinescu (researcher), Gérard Chollet (co-ordinator);

Description The SpeechDat project addresses the fields of production, standardization, evaluation and dissemination of Spoken Language Resource (SLR).

The goal of the present repository is to provide guidelines and recommendations issued from the work achieved in SpeechDat (focusing on telephone like applications) as well as from other relevant current or past initiatives (covering other applications). Among the deliverables of the project, recommendations will be available through different reports.

♢ Automatic Speaker Recognition over the Telephone Network

Official status European project, COST 250 action, supported by OFES;

Duration Oct. 1st, 1995 – Sep. 30, 1998;

Partners France, Italy, United Kingdom, Sweden, The Netherlands, Spain, Portugal, Ireland, Denmark, Greece, Slovenia, Switzerland, Turkey;

Internal staff Dominique Genoud (researcher), Gérard Chollet (co-ordinator);

Description This collaborative COST action aims at: (1) studying the technology, the economical and social feasibility of the use of Automatic Speaker Recognition /Verification technologies from speech utterances, (2) analyzing in detail the applications in telecommunications, (3) obtaining the needed databases to finalize and evaluate the automatic speaker recognition, (4) completing and transmitting between European laboratories the know-how in this field, and (5) elaborating demonstration prototypes of these technologies.

♢ Speech and speaker recognition over the telephone on SwissNet

Official status Swiss project, supported by CTI (formerly CERS);

Duration Sep. 1st, 1995 – Aug. 31, 1997;

Partners Sun Microsystems (Switzerland), aComm, Telecom PTT, EPFL, IDIAP;

Internal staff Olivier Bornet (research engineer), Jean-Luc Cochard (co-ordinator);

Description The goal of this project is to make speech/speaker recognition systems available on multi-processor workstations and SwissNet platform to industrial partners, and particularly to Swiss industry for Swiss French. The research addresses among others the problem of phonetic models for a speaker independent, vocabulary independent speech recognition system for telephone applications. The results are likely to be exploited for new Interactive Voice Server application to be configured by the Swiss Telecom PTT.

◊ Concurrent logic programming in automatic speech recognition

Official status Swiss project FN 21-37 467.93, supported by Swiss NSF;

Duration Oct. 1st, 1993 – Sep. 30, 1995;

Internal staff Dominique Genoud (researcher), Cédric Jaboulet (research engineer), Philippe Langlais (research assistant), Murielle Vial (research assistant);

Description The purpose of this research project is the setup of a system for continuous speech recognition, integrating design avantages of concurrent logic programming. This subject brings together two historically distinct research domains: logic programming and speech recognition. The general framework we intend to build, at the software level, will be used as a testbed for testing various approaches to the problem of continuous speech recognition (CSR).

We propose to test in depth the possibilities of some concurrent logic programming languages (CLPL) and thus to estimate the potential of CLP. We will for example implement different strategies of communication: blackboard method, point-to-point synchronous or asynchronous communication, broadcast communication. These different methods will be applied to our CSR problem with the idea of selecting the most appropriate method for implementing less constraining cooperation between different knowledge sources.

◊ $\mathsf{ETC}_{\mathsf{vérif}}$: a system to help labelling of speech corpora

Official status Swiss project FN 20-43 494.95, supported by Swiss NSF as follow-up project of FN 21-37 467.93;

Duration Nov. 1st, 1995 – Oct. 31, 1997;

Internal staff Murielle Vial (research assistant);

Description $\mathsf{ETC}_{\mathsf{vérif}}$ is a prototype of a continuous spoken language recognition system (CSLR). This work stems from the strong intuition that a probable solution to the general problem of speech understanding lies in the development of a system able to deal with a large set of distinct, partial and even unreliable problem solvers, namely HMMs (Hidden Markov Models), GTP (Graphemes To Phonemes) agents, prosodic analysers and even higher order agents processing syntactic and semantic knowledge.

The system $\mathsf{ETC}_{\mathsf{vérif}}$ under development at IDIAP, is implemented as a multi-agent system, and is based on a general purpose platform called ETC, for cooperative treatment environment ("Environnement de Traitement Coopératif"). The purpose of decomposing a continuous spoken language recognition system into two layers: a kernel that is application-independent and a periphery that bears all the knowledge of the application domains, will improve the design of a flexible and adjustable system.

$\mathsf{ETC}_{\mathsf{vérif}}$ is addressing a simplified problem of CSLR, namely verification of speech utterances. This concretely means that the input data of the system is twofold: the signal sample, on one side, and the text that had to be uttered, on the other side. This simplified context greatly reduces the required number of agents and the internal complexity of some agents that have to be developed. Nevertheless, many experiments can be conducted in this case that give us some valuable information on how to setup an entire and efficient CSLR system.

♢ $\mathsf{ETC}_{\mathsf{reco}}$: A system of automatic speech recognition over the telephone

Official status European project, COST 249 action, supported by OFES;

Duration Oct. 1st, 1995 – Sep. 30, 1998;

Partners Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, France, Greece, Hungary, Italy, Lithuania, Norway, The Netherlands, Portugal, Poland, Sweden, Slovakia, Slovania, United Kingdom;

Internal staff Dan Andrei Constantinescu (researcher);

Description $\mathsf{ETC}_{\mathsf{reco}}$ has to be understood as an extension of $\mathsf{ETC}_{\mathsf{vérif}}$ in many directions. First, its dedicated objective is to implement an effective continuous spoken language recognition system. Second, the set of knowledge source is larger than the above ones. Some efforts will be directed towards the integration of linguistic knowledge, namely statistical and rule-based ones. A third improvement will concern a better decomposition between the kernel of the system ETC and its surrounding modules. We hope this work to give rise to a real application independent multi-agent approach.

♢ ATTACKS – Advanced Technology in Teleservices with Access Control by a Key of Spoken digits or words

Official status Mandate of Swiss Telecom-PTT;

Duration Dec. 1st, 1994 – Sep. 30, 1995;

Partners Swiss Telecom-PTT, Dutch Telecom, Telia (Swedish Telecom);

Internal staff Dominique Genoud (researcher), Guillaume Gravier (student), Hubert Wassner (student), Philippe Le Hir (student), Gérard Chollet (co-ordinator);

Description The ATTACKS project goal was to provide a demonstrator of a multilingual speaker verification over the telephone for the Telecom 95 exhibition at Geneva in October 1995. The demonstrator is software-based, this implies no special hardware for speech processing. The demonstrator uses 2 levels of verification: text-dependent and text-independent approaches. The current version is running on Sun SPARC workstations. The verification process time is about 10 sec. on a Sun SPARC station 20 with 4 processors. As a first step, the customer is asked to pronounce his PIN code (7 digits). A speaker-independent speech recognition task takes place which output is an identification number. Then a text-dependent speaker verification can be done on the same speech sample. Currently, three text-dependent verification algorithms are used. All of them are processed in parallel; each algorithm gives a decision value and a confidence on its result. These three partial results are then combined to make a final decision: acceptation, rejection, or doubt. In case of doubt, the speaker is asked to answer a question and a text-independent verification is performed on this answer. No speech recognition is needed here and the final decision is taken with regards to this second level of verification.

Before the customer can access his account, he has to follow an enrolment procedure during which he is asked to record 5 times his PIN code and to record 2 sentences.

A small database has also been recorded in the context of this ATTACKS project. Its name is Polycode and it contains sequences of connected digits. Two distinct parts are available: noisy recording sessions (SNR around 0 db) and quiet recording sessions (SNR higher than 20 db).

◊ ATTACKS+

Official status Mandate of Swiss Telecom-PTT;

Duration Sep. 1st – Dec. 31, 1995;

Internal staff Mohamed Mehdi Homayounpour (researcher);

Description This project is an extension of the former ATTACKS project. It aims at resolving some of the problems that arise during the setup and evaluation phases of ATTACKS. Roughly, these problems deal with computation of a priori decision thresholds, silence suppression, and implementation of new algorithms for speaker verification.

◊ Polyphone – Recording and annotation of a Swiss-French speech corpus

Official status Mandate of Swiss Telecom-PTT;

Duration Feb. 1st, 1994 – Dec. 31, 1995;

Internal staff Catherine Delattre (annotator), Dilia Montipietra (annotator), Sandrine Dely (annotator), Anne Coquoz (annotator), Alexandra Bender (annotator), Cedric Jaboulet (research engineer), Gérard Chollet (co-ordinator);

Description The purpose of this project is to record a database of speech samples over the telephone. The database content and the size of the recorded population are determined in order to capture inter-speaker variability. 5 000 speakers pronouncing different types items (various numbers, isolated words, spelled names, sentences, spontaneous answers) have been recorded. The correctness of what has been said compared to the text prompts is done manually by a number of annotators using a dedicated homemade software, called Annotator. The deliverable of this project is a set of 10 CD-Rom containing 500 speakers each. Each record in this database is a pair of two element, a speech sample on one hand, and a written transcription, on the other.

◊ Polyphone-CHall – Recording and annotation of a German speech corpus

Official status Mandate of Swiss Telecom-PTT;

Duration Dec. 1st, 1995 – Dec. 31, 1996;

Partner TIK/ETH Zürich;

Internal staff Gilles Caloz (research engineer), Dan Andrei Constantinescu (researcher), Jean-Luc Cochard (co-ordinator);

Description Since IDIAP has already gained valuable experience in the Swiss-French Polyphone project, the huge amount of work for content specification, sheet preparation, speaker recruiting, speech recording, and annotation will be split between TIK and IDIAP. The tasks dedicated to IDIAP are the following ones:

Preparation of the prompting sheets: A lot of the addressed speakers finally don't call the automatic recording machine. In order to get still maximum statistically balanced speech material this has to be taken into account, i.e., the sheets have to be produced continuously. This task is done at IDIAP.

Tools: IDIAP will provide their tools used for text preparation and for speech annotation. In particular, IDIAP will support TIK to adapt the tools to the new requirements.

♢ FERRT – Features extraction and recognition in real-time

Official status Mandate of Swiss Telecom-PTT;
Duration Feb. 1st – Jun. 30, 1995;
Internal staff Olivier Bornet (research engineer);
Description This project aims at the implementation of more efficient versions of spectral analysis and Viterbi decoding algorithms in order to develop a real-time speech recognition system. The selected hardware plateform is a Sun-SPARC 20 with 4 processors connected to the Swiss ISDN telephone network.

♢ PolyVar – Recording and annotation of a Swiss-French corpus

Official status internally supported;
Duration Feb. 1st, 1994 –Jul. 31, 1996
Internal staff Sandrine Dely (annotator), Cédric Jaboulet (research engineer);
Description The objective of PolyVar is to create a database of speech samples designed to capture intra-speaker variability. The content and recording conditions of PolyVar are very similar to the ones of Polyphone. The population is however very different. Instead of 5 000 distinct persons, PolyVar initial goal was to have 100 recording sessions of 50 persons. This ideal distribution won't be reached even if we already have more than 3 000 recording sessions, verified and ready to be put on CD-Rom.

2.3 Vision

2.3.1 Main orientations of the research

Humans perform visual perception with fascinating performance. So, it is not surprising that numerous researchers are interested in understanding this phenomenon and to develop machines with similar capabilities. In the wide spectrum of machine vision, we have focused our research on the problematic of off-line handwriting recognition.

Although it is a sub-area of machine vision research, we believe that handwriting recognition faces many inherent problems of machine vision, for which there is still a lack of theory and which we express as:

- how to represent shape and how to measure similarity to achieve the best recognition rates?
- what is the optimal data/information reduction for knowledge?
- how to solve the segmentation/recognition dilemma?

Beside the theoretical interest just mentioned, we also consider applications of handwriting recognition. Our major interest is in recognizing ancient manuscripts. Indeed, we think that in the age of telematics, scientists and technicians should provide tools which allow a better access to the huge heritage received from our ancestors in the form of written documents.

2.3.2 Research projects

♢ Optical Character Recognition

Funding Swiss National Foundation for Scientific Research, 21-39576.93
Duration April 94 – March 96
Internal staff Dr. Thomas M. Breuel (task manager), Dr. Gilbert Maître
Description The goal of this project is to build a character recognition module that performs significantly better than existing systems in complex OCR tasks, i.e. in the presence of interfering strokes, or in writing styles that are difficult to segment.

♢ M2VTS (see section 2.2.2)

3 Educational activities

3.1 Workshop Lecturing

- **Workshop title** Workshop on Neural Network Analysis & Design
  Invited Speaker Emile Fiesler
  Location University of Geneva, Geneva
  Dates January 9–10, 1995

3.2 Doctoral thesis

- **Ph.D. Candidate** David Elizondo
  Supervisor Emile Fiesler
  Research topic Sparse Neural Networks
  University Louis Pasteur University, Strassbourg, France

- **Ph.D. Candidate** Perry Moerland
  Supervisor Emile Fiesler
  Research topic Neural Networks for Hardware
  University EPFL (preliminary)

- **Ph.D. Candidate** Philippe Langlais
  Title Traitement de la prosodie en reconnaissance de la parole
  University Université d'Avignon et des Pays de Vaucluse
  Examination date Oct. 11, 1995
  Remark Final part of this work has been done during a training period at IDIAP

- **Ph.D. Candidate** Georg Thimm
  Supervisor Emile Fiesler
  Research topic Ontogenic High Order Neural Networks
  University EPFL, Lausanne

3.3 Lectures

- **Title** Serveurs vocaux interactifs et vérification de l'identité du locuteur
  Speaker Gérard Chollet
  School École polytechnique fédérale de Lausanne
  Date January 13, 1995
  Audience Students of electrical engineering department

- **Title** Outils informatiques pour le traitement automatique de la langue naturelle
  Speaker Jean-Luc Cochard
  School University of Fribourg
  Duration 1st and 2nd trimesters of 1994–1995 academic year
  Audience 3rd and 4th year optional course for students in computer science

- **Title** Nouvelle approche du dialogue homme-machine, l'intelligence artificielle perceptive
  Speaker Jean-Luc Cochard
  School École supérieure d'informatique de gestion, Sierre
  Date August 24, 1995
  Audience Students, former students and professors

- **Title** Neural Networks for Optical Computers
  Speaker E. Fiesler
  Location University of Berne
  Date January 24, 1995

- **Title** Towards All-Optical Neural Networks.
  Speaker I. Saxena
  Location Group of Applied Physics, University of Geneva,
  Date March 10, 1995

- **Title** Adaptive Multilayer Optical Neural Networks.
  Speaker I. Saxena
  Location Ascom Tech, Bern,
  Date November 8, 1995

3.4 Examinations

- **School** Université d'Avignon et des Pays de Vaucluse
  Subject Doctoral thesis examination
  Expert Gérard Chollet
  Candidate Philippe Langlais
  Thesis title Traitement de la prosodie en reconnaissance de la parole
  Date Oct. 11, 1995
  Remark thesis accepted with "congratulations of the jury"

- **School** Université Henri Poincaré, Nancy I
  Subject Thesis report
  Expert Jean-Luc Cochard
  Candidate Roselyne Nguyen
  Thesis title Un système multi-agent pour la machine a dicter vocale MAUD : conception et intégration d'une source de connaissances phonologiques
  Date Sep. 4, 1995
  Remark A set of improvements has been required in order to be accepted

- **School** EPFL
  Subject Traitement de la parole
  Expert Jean-Luc Cochard
  Candidates 3rd year students in electrical engineering
  Date Sep. 29, Oct. 2nd, 1995

- **School** École supérieure d'informatique de gestion (ESIS), Sierre
  Subject Practical projects
  Expert Jean-Luc Cochard
  Candidates Diploma final examination session after 2 years
  Date Jun. 28, 1995

- **School** EPFL
  Subject Diplom examination
  Expert E. Fiesler
  Candidate Stéphane Cuche
  Thesis Title Generalized Cauchy Machines
  Date March 20th, 1995

- **School** EPFL
  Subject Internship examination
  Expert G. Thimm and E. Fiesler
  Candidate Jean-Luc Beuchat
  Thesis Title Optimisation de réseaux neuronaux
  Date November 1st, 1995

- **School** EPFL
  Subject Artificial and Biological Neural Networks
  Expert Eddy Mayoraz
  Candidates Diploma final examination session, students in mathematics, computer science and electrical engineering
  Date Sep. 21, 1995

3.5 Traineeships

- **Trainee** Jean-Luc Beuchat
  School EPFL
  Formation Pre-diploma work
  Subject Multilayer Neural Network Pruning
  Duration Jul. – Oct. 1995
  Responsible G. Thimm and E. Fiesler

- **Trainee** Stéphane Brunet
  School Université de Rennes I, Institut de Formation Supérieure en Informatique et Communication (IFSIC), Campus de Beaulieu, 35042 RENNES CEDEX
  Formation DESS Informatique et Ses Applications (ISA)
  Subject Apprentissage de prototypes de caractères à partir de l'image d'un texte manuscrit et avec l'aide d'un opérateur
  Duration Mar. – Jun. 1995
  Responsible G. Maître

- **Trainee** Rachel Fournier
  School University of Fribourg
  Formation Third year project
  Subject Analyse syntaxique concurrente en Oz
  Duration Oct. 1994 – Mar. 1995
  Responsible J.-L. Cochard

- **Trainee** Grégoire Cosandey
  School EPFL
  Formation Diploma thesis
  Subject Reconnaissance de la parole dans le bruit
  Duration Nov. 1994 – Feb. 1995
  Responsible G. Chollet, A. Drygajlo

- **Trainee** Stéphane Cuche
  School EPFL
  Formation Diploma thesis
  Subject Generalized Cauchy Machines
  Duration Nov. 1994 – Feb. 1995
  Responsible E. Fiesler

- **Trainee** Rachel Fournier
  School University of Fribourg
  Formation Diploma thesis
  Subject Étude de paramètres prosodiques en reconnaissance automatique de l'allemand
  Duration Oct. 1995 – Jul. 1996
  Responsible J.-L. Cochard

- **Trainee** Guillaume Gravier
  School École nationale supérieure de l'électronique et de ses applications (ENSEA), 6, avenue du ponceau 95014 Cergy CEDEX - France
  Formation DEA
  Subject Vérification du locuteur par modèles de Markov cachés gauche-droite
  Duration Apr. – Jul. 1995
  Responsible G. Chollet, D. Genoud

- **Trainee** Olivier Grenèche
  School École Supérieure Ingénieur Electrotechnique et Electronique (ESIEE)
  Formation 4th year training period
  Subject Vérification du locuteur dépendant du texte à l'aide de HMMs ergodiques
  Duration May – Jul. 1995
  Responsible G. Chollet

- **Trainee** Katrin Keller
  School University of Illmenau, Germany
  Formation Pre-diploma work
  Subject Discrete Ontogenic Neural Networks for Telecommunication
  Duration Aug, 1995 – Feb. 1996
  Responsible E. Fiesler

- **Trainee** Philippe Le Hir
  School Ecole Supérieure d'Informatique-Electronique-Automatique (ESIEA) 9, rue Vésale, 75005 Paris,
  Formation 5th year training period
  Subject Approche globale et approche vocabulaire flexible pour la reconnaissance automatique de la parole
  Duration Mar. – Dec. 1995
  Responsible G. Chollet

- **Trainee** Miguel Moreira
  School Minho University, Portugal
  Formation Diploma thesis
  Subject Dynamic Neural Network Parameter Adaptation
  Duration Feb. – Nov. 1995
  Responsible E. Fiesler

- **Trainee** Dinh Van Linh Nguyen
  School University of Fribourg
  Formation Diploma thesis
  Subject Environnement de mise au point d'objets Oz
  Duration Oct. 1994 – Jul. 1995
  Responsible J.-L. Cochard

- **Trainee** Lyse Robadey
  School University of Fribourg
  Formation Diploma thesis
  Subject Établissement de modèles statistiques du français écrit
  Duration Oct. 1994 – Jul. 1995
  Responsible J.-L. Cochard

- **Trainee** Murielle Vial
  School École nationale supérieure des télécommunications (ENST), 46 rue Barrault, 75634 Paris cedex 13
  Formation Diploma thesis
  Subject Définition et évaluation d'un protocole de négociation dans un système multi-agents de reconnaissance de la parole
  Duration Jan. – Jun. 1995
  Responsible J.-L. Cochard

- **Trainee** Hubert Wassner
  School Ecole Supérieure d'Informatique-Electronique-Automatique (ESIEA) 9, rue Vésale, 75005 PARIS,
  Formation 5ème année
  Subject Etude sur la paramétrisation du signal en Traitement Automatique de la Parole (TAP)
  Duration Mar. – Dec. 1995
  Responsibles G. Chollet, G. Maître

- **Trainee** Peter Weber
  School University of Illmenau, Germany
  Formation Pre-diploma work
  Subject User-Interface Management System for Neural Network Simulator
  Duration Aug. 1995 – Feb. 1996
  Responsible E. Fiesler

4 Other scientific activities

4.1 Editorships

- **Name** Emile Fiesler
  Function Editor-in-Chief
  Book title Handbook of Neural Computation
  Publisher Oxford University Press and Institute of Physics

- **Name** Daniel Osherson
  Function General Editor of the four volumes and co-editor of volumes 3 and 4
  Book title An Invitation to Cognitive Science
  Publisher M.I.T. Press, Cambridge, MA

- **Name** Georg Thimm
  Function Current Events Editor
  Journal Neurocomputing
  Publisher Elsevier

- **Name** Eddy Mayoraz
  Function Member of the Editorial Board
  Conference European Symposium of Artificial Neural Networks

4.2 Organisation of conferences

- **Title** WOz'95: International Workshop on Oz Programming
  Location Martigny, Town hall
  Date Nov. 29 – Dec. 1st, 1995
  Organisation Jean-Luc Cochard, Rolf Ingold (University of Fribourg)
  Program Committee Jean-Luc Cochard, Michèle Courant (Univ. Fribourg), Klaus Fischer (DFKI, Saarbrücken, D), Martin Henz (DFKI, Saarbrücken, D), Beat Hirsbrunner (Univ. Fribourg), Pierre Kuonen (EPFL), Michael Mehl (DFKI, Saarbrücken, D), Jacques Menu (Univ. & Hospices Cantonaux, Lausanne), Stephen Spackman (DFKI, Saarbrücken, D), Laurent Trilling (IMAG-LGI, Grenoble, F)
  Sponsors Troisième cycle romand d'informatique, SIPAR, SUN Microsystems Inc., Daimler-Benz AG, Compulog Net
  Contributions 18 oral presentations
  Audience 42 participants

4.3 Software dissemination

- **Name** Annotator
  Description Annotator is a software tool developed for the purpose of verifying and correcting the transcription of utterances. The Annotator interface works under SunOS or Solaris on SUN workstations. Those must have audio equipment. Moreover, the annotation tool requires an installed version of Xwaves from Entropic and the public domain package Tcl-Tk.
  Documentation Readme file and "Le Guide du 'Polyphone manager'", Cédric Jaboulet, unpublished document, IDIAP, 1995
  Distributed to
  - Vocalis Limited, Chaston House, Mill Court, Station Road, Great Shelford, Cambridge, United Kingdom
  - INESC, Instituto de Engenharia de Sistemas e Computadores, Rua Alves Redol, 9, 1000 Lisboa, Portugal

4.4 Collaboration with local companies

- **Company's Name** GPIL, Gianni Pante Ingénierie du Logiciel
  Company's Address 6, rue du Grand Verger, 1920 Martigny
  Description Prototyping of a machine vision system for quality control.
  Internal staff Gilbert Maître and Emile Fiesler

5 Events and Presentations

- **Title** ETC_reco: A multi-agents approach to spoken language recognition
  Speaker Jean-Luc Cochard
  Event COST 249 meeting
  Location Nancy
  Dates March 6–7, 1995

- **Title** Un prototype multi-agents de reconnaissance automatique de la parole
  Speaker Jean-Luc Cochard
  Event Journée Systèmes Multi-Agents et Communication Homme-Machine
  Location Grenoble
  Date May 19, 1995
  Remark Joint meeting of GDR-PRC CHM et working group MARCIA of GDR-PRC IA

- **Title** Les domaines d'application des technologies vocales
  Speaker Gérard Chollet
  Event Fondements et Perspectives en Traitement Automatique de la Parole
  Location Marseille
  Dates July 17–25, 1995
  Remark Summer school

- **Event** Fondements et Perspectives en Traitement Automatique de la Parole
  Participants Jean-Luc Cochard, Philippe Langlais
  Location Marseille
  Dates July 17–25, 1995
  Remark Attendance to this summer school

- **Title** The Coverage Requirements for the Swiss Polyphone Database and its Annotation Environment
  Speaker Jean-Luc Cochard
  Event COST 249 meeting
  Location Madrid
  Dates September 14–15, 1995

6 Publications

6.1 Book chapters

[Cho95b] Gérard Chollet. Les domaines d'application des technologies vocales. In *Fondements et perspectives en traitement automatique de la parole*. GDR-PRC Communication Homme-Machine, 1995.

[CB95] Gérard Chollet and Frédéric Bimbot. Assessment of speaker verification systems. In *Spoken Language Ressources and Assessment*. EAGLES Handbook, 1995.

[OSW95] Daniel Osherson, Michael Stob, and Scott Weinstein. Logic and learning. In S. Hanson, G. Drastal, and R. Rivest, editors, *Computational Learning Theory and Natural Learning Systems*. M.I.T. Press, Cambridge MA, 1995.

[TK95] Kari Torkkola and Teuvo Kohonen. A hybrid approach to continuous speech recognition. In Michael A. Arbib, editor, *The handbook of brain theory and neural networks*. The MIT Press, 1995.

[Osh95] Daniel Osherson. Probability judgment. In Daniel Osherson and Edward E. Smith, editors, *Invitation to Cognitive Science: Thinking (Second Edition)*. M.I.T. Press, Cambridge MA, 1995.

6.2 International journals

[CM95] Gérard Chollet and Ch. Mokbel. Automatic word recognition in cars. *IEEE Speech and Audio Processing*, 1995.

[CF] S. Cuche and E. Fiesler. Generalized cauchy machines. *Neurocomputing*. submitted.

[MA96] Eddy Mayoraz and Frédéric Aviolat. Constructive training methods for feedforward neural networks with binary weights. *International Journal of Neural Systems*. to appear in 1996.

[May96b] Eddy Mayoraz. On the power of democratic networks. *SIAM Journal of Discr. Math.* to appear in May 1996.

[MFS] P. Moerland, E. Fiesler, and I. Saxena. Incorporating LCLV non-linearities in optical multilayer neural networks. *Applied Optics*. Accepted for publication.

[OSS+95] Daniel Osherson, Edward Smith, Eldar Shafir, Antoine Gualtierotti, and Kevin Biolsi. A source of Bayesian priors. *Cognitive Science*, 19: 377 – 405, 1995.

[OW95a] Daniel Osherson and Scott Weinstein. On the danger of half-truths. *Journal of Philosophical Logic*, 24: 85–115, 1995.

[OW95b] Daniel Osherson and Scott Weinstein. On the study of first language acquisition. *Journal of Mathematical Psychology*, 39(2): 129 – 145, 1995.

[ST] I. Saxena and R. B. Torbert. Time resolved polarimetry on an optical fiber ammeter. *Journal of the European Optical Society*. in press.

[SF95a] I. Saxena and E. Fiesler. Adaptive multilayer optical neural network with optical thresholding. *Optical Engineering*, 34(8): 2435–2440, August 1995. Invited paper.

[TF] G. Thimm and E. Fiesler. High order and multilayer perceptron initialization. *IEEE Transactions on Neural Networks*. Accepted for publication.

[TMF96] G. Thimm, P. Moerland, and E. Fiesler. The interchangeability of learning rate and gain in backpropagation neural networks. *Neural Computation*, 8(2): 451–460, 1996.

6.3 Conferences Proceedings

[BLM95] Frédéric Béchet, Philippe Langlais, and Henri Méloni. Lexical filtrering by means of prosodic information. In *International Congress of Phonetic Sciences*, Stockholm, Sweden, August 13–19 1995.

[CH95a] G. Chollet and M. Homayounpour. Discrimination of the voices of twins and siblings for speaker verification. In *4th European Conference on Speech Communication and Technology*, Madrid, Spain, Sep 1995.

[CH95b] G. Chollet and M. Homayounpour. Neural nets approaches to speaker verification: comparison with second order statistical measure. In *ICASSP*, Detroit, 1995.

[CH95c] G. Chollet and M. Homayounpour. A study of intra- and inter-speaker variability in the voices of twins for speaker verification. In *International Congress of Phonetic Sciences*, Stockholm, Aug 1995.

[CF95a] Jean-Luc Cochard and Philippe Froidevaux. Environnement multi-agents de reconnaissance automatique de la parole en continu. In *Actes des 3èmes Journées Francophones sur l'Intelligence Artificielle Distribuée et les Systèmes Multi-agents*, pages 101–110, mars 1995.

[CCLv95] G. Chollet, J.-L. Cochard, Ph. Langlais, and R. van Kommer. Swiss-french polyphone: a telephone speech database to develop interactive voice servers. In *Linguistic Databases*, Groningen, 1995.

[CN95] Jean-Luc Cochard and Dinh Van Linh Nguyen. A graphical tool for monitoring Oz objects activity. In IDIAP Jean-Luc Cochard, editor, *Proc. of WOz'95: International Workshop on Oz Programming*, pages 97–99. IDIAP, Uni. Fribourg, Nov 1995.

[CO95] Jean-Luc Cochard and Olivier Oppizzi. Reliability in a multi-agent spoken language recognition system. In *4th European Conference on Speech Communication and Technology*, Madrid, Spain, Sep 1995.

[CV95] Jean-Luc Cochard and Murielle Vial. Etc_vérif, a prototype of a cooperative automatic speech recognition system. In IDIAP Jean-Luc Cochard, editor, *Proc. of WOz'95: International Workshop on Oz Programming*, pages 25–33. IDIAP, Uni. Fribourg, Nov 1995.

[CF95b] S. Cuche and E. Fiesler. Ontogenic high order cauchy machines. In Nicolas Droux, editor, *Proceedings of the SIPAR Workshop '95: Parallel and Distributed Systems*, pages 113–116, Biel, Switzerland, 1995. Biel School of Engineering.

[EFK95] D. Elizondo, E. Fiesler, and J. Korczak. Non-ontogenic sparse neural networks. In *Proceedings of the International Conference on Neural Networks*, volume 1, pages 290–295, Piscataway, NJ, 1995. IEEE.

[Lan95] Philippe Langlais. Microprosodic study of isolated French word corpora. In *4th European Conference on Speech Communication and Technology*, Madrid, Spain, September 18–21 1995.

[LC95] Philippe Langlais and Jean-Luc Cochard. The use of prosodic agents in a cooperative automatic speech recognition system. In *International Congress of Phonetic Sciences*, Stockholm, Sweden, August 13–19 1995.

[MO95] Eric Martin and Daniel Osherson. A note on the use of probabilities by mechanical scientists. In Paul Vitányi, editor, *Computational Learning Theory: Second European Conference, EuroCOLT '95 (Barcelona, Spain)*. Springer: Lecture Notes in Artificial Intelligence 904, Berlin, 1995.

[May96a] Eddy Mayoraz. Bounds on the degree of high order binary perceptrons. In François Blayo and Michel Verleysen, editors, *Proceedings of ESANN'96*. D facto, 1996.

[MF96] P. Moerland and E. Fiesler. Hardware-friendly learning algorithms for neural networks: An overview. In *Proceedings of the Fifth International Conference on Microelectronics for Neural Networks and Fuzzy Systems: MicroNeuro'96*, pages 117–124, 10622 Los Vaqueros Circle, Los Alamitos, CA 90720, 1996. EPFL and CSEM, IEEE Computer Society Press.

[MFS95] P. Moerland, E. Fiesler, and I. Saxena. The effects of optical thresholding in backpropagation neural networks. In F. Fogelman-Soulié and P. Gallinari, editors, *Proceedings of the International Conference on Artificial Neural Networks (ICANN'95 and NeuroNîmes'95)*, volume 2, pages 339–343, 31, Place Ronde, 92986 Paris La Défense, France, 1995. ENNS, EC2 & Cie.

[OM95] Daniel Osherson and Eric Martin. Scientific discovery via rational hypothesis revision. In Maria Luisa Dalla Chiara, editor, *Proceedings of the 10th International Congress of Logic, Methodology, and Philosophy of Science (Florence, Italy)*, August, 1995.

[PTF96] A. De Pol, G. Thimm, and E. Fiesler. Sparse initial topologies for high order perceptrons. In *Proceedings of the International Conference on Neural Networks*. IEEE, 1996. in press.

[PTF95] A. De Pol, G. Thimm, and E. Fiesler. Boolean logic inspired high order perceptron construction. In Nicolas Droux, editor, *Proceedings of the SIPAR Workshop '95: Parallel and Distributed Systems*, pages 117–120, Biel, Switzerland, 1995. Biel School of Engineering.

[SF95b] I. Saxena and E. Fiesler. An all-optical forward propagation multilayer neural network. In J. Mira and F. Sandoval, editors, *From Natural to Artificial Neural Computation*, volume 930 of *Lecture Notes in Computer Science*, chapter 7. Implementation, pages 807–814. Springer Verlag, Berlin, 1995.

[SFCP95] I. Saxena, E. Fiesler, N. Collings, and A. Pourzand. Optical multilayer perceptrons based on liquid crystal devices. In *Optics and Information*, volume 6 of *EOS Topical Meetings Digests Series*. Cercle SFO/SEE d'Opto-informatique, European Optical Society (EOS), 1995.

[TF95b] G. Thimm and E. Fiesler. Neural network initialization. In J. Mira and F. Sandoval, editors, *From Natural to Artificial Neural Computation*, volume 930 of *Lecture Notes in Computer Science*, chapter 4. Learning, pages 535–542. Springer Verlag, Berlin, 1995.

[TF95a] G. Thimm and E. Fiesler. Evaluating pruning methods. In *1995 International Symposium on Artificial Neural Networks (ISANN'95)*, pages A2 20–25, 1995.

[TFM95] G. Thimm, E. Fiesler, and P. Moerland. Gain elimination form backpropagation neural networks. In *Proceedings of the International Conference on Neural Networks*, volume 1, pages 365–368, Piscataway, NJ, 1995. IEEE.

6.4 Technical reports

[Bru95] Stéphane Brunet. Apprentissage de prototypes de caractères à partir de l'image d'un texte manuscrit et avec l'aide d'un opérateur. Technical Report 95-01, IDIAP, Juin 1995.

[Via95] Murielle Vial. Définition et évaluation d'un protocole de négociation dans un système multi-agents de reconnaissance de la parole. Technical Report 95-02, IDIAP, Martigny, Switzerland, 1995.

[Maî95] Gilbert Maître. Experiments with robust similarity measures for OCR. Technical Report 95-03, IDIAP, June 1995.

[MF95] M. Moreira and E. Fiesler. Neural networks with adaptive learning rate and momentum terms. Technical Report 95-04, IDIAP, Martigny, Switzerland, October 1995.