



## Speech Technology in Europe

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### Abstract

The aim of this paper is to furnish an overview of the efforts conducted in Europe in the field of Speech Technology, and to compare it briefly with the efforts in the US and Japan.

### Introduction

The efforts of European countries in Speech Technology are manifold. As Europe is a mosaic of small countries, each one having one or several different languages, automatic language processing, including voice processing, may be considered as a priority, in the framework of building a community of countries, without destroying the cultural heritage, and future of each of them.

### The European Speech Technology Effort

I have conducted an analysis of the IEEE Annual International Conferences on Acoustics, Speech and Signal Processing (ICASSP), from the first issue in 1976 to the present year (1987). This congress is organised by the IEEE which is basically a US, though internationally installed, society of Electrical and Electrotechnical Engineers. The conference is devoted to 3 different topics (General Signal Processing, Image Processing and Speech Processing).

In 1987, 1200 papers were submitted (half of them from outside the US), and 600 papers were accepted. On the average, 1/3 of the papers are on Speech Processing. On the average, 53% of the papers presented on Speech Processing are US, 25% European, and 12.5% Japanese. This makes a total of 90% of the papers. However, when the conference takes place outside the US (it has already happened twice), those percentages may vary dramatically. In 1982, in Paris, 40% of the papers were US, 40% European, and 8.5% Japanese. In 1986, in Tokyo, 34% of the papers were US, 27.5% European, and 31.75% Japanese.

This analysis may furnish an idea of the relative efforts conducted in different countries in the world. All the papers are reviewed by a scientific committee, and the conference is considered to be of high quality. Some biases are present however: those conferences deal with Electrical Engineering, and the Phonetics laboratories may be disadvantaged. The choice of the papers is made by a US program committee (when it takes place in the US), and the non-US papers may be disadvantaged. Papers must be written in English, and non English-speaking countries are disadvantaged. Thus, the following data should be considered as very coarse elements of information, and absolutely not as quality ratings of laboratories around the world.

An analysis of the US papers shows that the 10 most active (in terms of publications) US laboratories produce 52% of the US Contribution (that is 25% of the worldwide contribution). Those are : AT&T-Bell Laboratories (17%), BBN (7%), MIT (6%), CMU, IBM , Lincoln Labs , Texas Instruments (4% each), Georgia Tech. (Atlanta) , GTE , ITT (2% each).

A similar analysis of the European papers shows that the 12 most active European laboratories (in terms of ICASSP publications) produce 46% of the European contribution (that is 12% of the worldwide contribution). Those are : CNET (Fr.) (8%), CSELT (Ital.) (6%), ENST (Fr.) (5%), Philips-Hamburg (FRG), LIMSI/CNRS (Fr.), Technical Universities of Munich (FRG) and Helsinki (Fin.)

(3.5% each), University of Cambridge (UK) (3%), CRIN (Fr.), KTH (Sweden), IBM-LaGaude (Fr.), and INESC (Portugal) (2.5% each). Assembling laboratories belonging to the same international company gives the following changes : Philips (6%) (with Philips-Eindhoven and Philips/MBLE-Brussels), IBM (6%) (with IBM-Paris and Rome Scientific Centers, and IBM-UK), raising the contribution of the 12 laboratories to 52%. This shows that Telecommunications laboratories are very active in the field, followed by computer science laboratories.

Doing the same analysis for the countries, it appears that France is responsible for 31% of the european papers, FRG for 17%, Italy for 12%, UK for 11%, Sweden for 6% and The Netherlands for 4%.

### **International coordination within Europe: Societies, Programs and Journals.**

There are some Scientific Societies or groups which exist at the European level : the FASE (Federation of National Acoustics Societies), the Eurasp Association which is generally devoted to Speech Processing and organizes conferences on this topic (EUSIPCO) and has a journal published by North-Holland "Signal Processing" (M. Kunt, Editor), the COST 209 (a research group on Telecommunications (G. Pirani, 1986). Some Ad-hoc committees organize conferences like the ECAI (European Conference on Artificial Intelligence), or the ACL (Association for Computational Linguistics), a US Society with a set of European members which organised a European Conference in Italy in 1983. Large Research & Development programs have been initiated by the European Community, especially in the ESPRIT project (J. Raukens, 1986, 1987, G. Modena, 1986), but also in the RACE project. Some speech technology projects are also present in the EUREKA program. The North-Holland publishing company has a publication related to speech, with an international scope, especially at the european level : "Speech Communication" (M. Wajskop Editor).

It may be thus noted that, apart the present conference, there is neither a regular European conference on Speech Sciences and Technology, nor a European Association on this topic as yet.

### **National Societies, programs and Conferences.**

At the national level, some countries have scientific associations, or coordinated activities on Speech Technology. To my knowledge, they are the following :

**France** : A subgroup of the French Society of Acoustics (SFA/GCP) organizes an Annual Conference on Speech (JEP), and Specialised Workshops on different topics related to Speech Processing. The AFCET association for Computer Science has a Working Group on "Speech Hardware and Software Architectures". The AFCET association organizes conferences on Artificial Intelligence and Pattern Recognition with sessions on Speech. The ARC (Association for Cognitive Research) organizes specialized workshops and has some interest in speech and Natural Language processing. The SEE (French Society of Electrical and Electrotechnical Engineers) has a Group 29 on Signal Processing, including speech.

The GRECO/CNRS 39 is a CNRS structure to coordinate the national effort on Speech Technology. It has its own budget from CNRS (National Research Agency), and the ministry of Industry (JP Haton, 1986, R. Carré, 1987).

**UK** : The Institute of Acoustics organizes conferences on Speech. It has a special group on the Assessment of Speech Technology (STAG). The IEE (Institute of Electrical Engineers) also has activities in the field. A national Alvey Program coordinates cooperative projects putting together Public research and industrial laboratories (J. Holmes, 1986, F. Fallside, 1987). 6 different projects involving Speech Technology are presently under development.

FRG : The DAGA (Acoustics Society) organizes workshops on speech. The large SPICOS project includes the Philips laboratory in Hamburg, the Siemens laboratory in Munchen, and IPO in Eindhoven on a common research for Continuous Speech Recognition (H. Mangold, 1987).

The Netherlands : A phonetic society exists with about 80 members (L. Pols, 1987). An acoustical society (NAG) has also workshops in this domain. The SPIN project on Speech Analysis and Synthesis includes five partners (Phonetic institutes of Amsterdam, Leiden, Nijmegen, Utrecht and IPO in Eindhoven), on a coordinated research program. In a related field, the CELEX (Centre for Lexical Information) project is intended to offer multilingual lexical databases access.

Denmark : Since 1983, a project on Speech recognition has been supported by the Danish council for Scientific and Industrial Research, with 3 major Danish industrial partners (Elbau, Jutland Telephone, and STL), and the Speech Technology Center of the University of Aalborg (P. Dalsgaard, 1987). A Project on Speech Recognition has been proposed to the Nordic Industrial Fund (NIF). It would involve Denmark (Jutland Telephone and the Speech Technology Center) and Norway (Elektrisk Bureau and ELAB). Contact will also be established with Swedish Industry. The Danish Teletechnical Society is also involved in scientific activities related to speech (like organizing the Aarhus workshop in 1987).

### Projects in the US and Japan

In the US, a major project on Speech Understanding Research has already been conducted within the DoD Darpa agency from 1971 to 1976. A new 5-10 year Darpa project started in 1984 (A. Sears, 1986). Complementary developments may arrive in the future (J. Baker, 1987).

In Japan, Speech was part of the Fifth Generation Computer project, launched in April 1982, but it seems that little progress has been reported since, in the framework of this project (T. Moto-Oka, 1984, J. Mariani, 1984). A new very ambitious project on automatic telephone interpretation has been recently started at the ATR (Advanced Telecommunications Research Institute International) laboratory, in Osaka. The budget that ATR will procure by 1989 from investors (in industry and elsewhere) is approximately 100 M\$ (A. Kurematsu, 1987). A national project has also been launched (H. Fujisaki, 1987).

### The laboratories

This list is not exhaustive, and I apologize in advance for the missing laboratories. Also the study has not been extended to Eastern Europe countries (Poland, Hungary, Czechoslovakia...). The accent has been placed on Automatic Speech Processing, rather than on linguistics per se. The activities of each laboratory are not presented. One may refer for further details, or for laboratories addresses, to a previous article (J. Mariani, 1985-1986). 233 laboratories are listed here, 141 public, and 92 industrial. The proportion of public laboratories versus industrial ones may be found to be higher than in the US or Japan. The manpower on Speech Technology may be evaluated nowadays at 1500 people in Europe (both academic institutions and industrial companies).

#### Austria(1)

*Public Laboratories* (1) : Technological University of Vienna (4 different Departments)

#### Belgium(9)

*Public laboratories* (7) : University of Antwerp, Université Libre de Bruxelles (Brussels) (Phonetic Institute and Faculty of Applied Sciences), University of Ghent, University of Leuven, University of Liège (Laboratory of

General Physics), University of Mons (Department of Phonetics and PsychoAcoustics, and department of Electrical Engineering), Vrije University (Brussels).

*Industrial Research and Development laboratories (2) : Philips / MBL (Brussels), ACEC (Charleroi)*

#### Denmark (6)

*Public Laboratories (2) : University of Aalborg (Speech Technology Center, Institute of Electronics), University of Copenhagen (Institute of Phonetics).*

*Industrial Research and Development laboratories (4): Phonic Ear International (Copenhagen), Jutland Telephone Company (Aarhus), Elbau, Standard Elektrik Kirk*

#### Finland (3)

*Public Laboratories (2): Technological University of Helsinki (Acoustics Lab, Technical Physics, Electrical Engineering Dpts), Tampere University of Technology (Electrical Engineering)*

*Industrial Research and Development laboratories (1): Euroka Oy*

#### France (45)

*Public Laboratories (19) : CERFIA (Toulouse University), CNET (Lannion, 3 Departments (RCP, ATP, Coding)), CRIN (Nancy University), ENST (Paris, Department SYC), ICP / ENSERG (Grenoble), LIMSI / CNRS (Orsay), CEN (Saclay), Paris VI University (Computer Science Department), IRCAM (Paris), Le Mans University, GIA (Marseille University), IRISA (Rennes), LASSY (University of Nice), University of Paris XIII (Electronics Institute), Phonetic Institutes (Aix-en-Provence, Grenoble, Nancy, Strasbourg, Paris) .*

*Industrial Research and Development laboratories (26) : CGE (Marcoussis), Telic-Alcatel, Thomson (DTC and DASM departments and Thomson TITN), IBM (La Gaude and Paris Scientific Center), Ferma (Paris), XCOM (Grenoble), Vecsys (Bièvres), Matra Communications, Ediciel, LCT, CGCT, TRT, Texas Instruments (Villeneuve-Loubet), SILEC, Kempf, Renault (DAST-Rueil), Jeumont-Schneider (Montceaux-les-Mines) , Crouzet (Valence), Electrel, CêNA, SNCF Etudes et Recherche, Rénix, OROS (Grenoble), SYSTEX.*

#### Federal Republic of Germany (39)

*Public laboratories (25) : Technical University (Berlin), University of Bielefeld, University of Bonn, University of Braunschweig, University of Bremen, Technische Hochschule (Darmstadt), University of Erlangen, University of Frankfurt (Physics Department), University of Giessen, University of Göttingen (Drittes Physikalisches Institut), University of Hamburg, University of Hannover, Karlsruhe University, University of Kiel, University of Köln, Philips University of Marburg, Technical University of Munich (Information Processing Institute and Acoustics departments), Ruhr University at Bochum, Fraunhofer- Institut für Informations- und Datenverarbeitung (Karlsruhe), Fraunhofer- Institut für Arbeitswirtschaft und Organisation (IAO) (Stuttgart), Fraunhofer- Institut für Produktionstechnik und Automatisierung (IPA) (Stuttgart), Heinrich-Hertz Institut (Berlin), Bundeskriminalamt BKA (Bonn), Bundespost (Darmstadt).*

*Industrial Research and Development laboratories (14) : AEG (Ulm, Konstanz), Siemens (Munich), Computer Gesellschaft Konstanz (Konstanz), Philips Forschung Laboratorium (Hamburg), Speech Design GmbH (Germering), Gerb Elektronik (Munich), Volkswagen (Wolfsburg), Ford (Köln), Dr Sasse GmbH, Gesellschaft für Elektronische Sprachsysteme mbH (GSP, Berlin), STAC*

Elektronische Systeme GmbH (Düsseldorf), Ultratronik Entwicklungs GmbH (Seefeld), Standard Elektrik Lorenz AG (SEL, Stuttgart), Beratungsbüro für ergonomische und akustische Fragen (Karlsruhe).

Greece (3)

*Public Laboratories* (3) : Technical University of Athens, University of Patras (Automation, Robotics, and Signal Processing Research Group and Wire Communications Lab), Research Center of Crete (Institute of Computer Science)

Ireland (3)

*Public Laboratories* (3) : University College of Dublin, University College of Galway , National Institute for Higher Education

Italy (20)

*Public Laboratories* (10) : University of Torino (Institute del Scienze del Informazione), Polytechnico Institute di Torino (Signal Processing Department), Interuniversity Linguistic Center of Venice , University of Napoli, University of Padova, University of Roma (INFOCOM), CNR (institutes of Psychology and of Acoustics (Roma), institute of Phonetics (Padova)), Fondazione Hugo Bordoni (Roma).

*Industrial Research and Development laboratories* (10) : CSATA (Bari), CSELT (Torino), ELSAG (Genova), Olivetti (Torino), IBM Rome Scientific Center, ITALTEL SIT, FACE Research Center (Pomezia), Fincantieri (Trieste), ZELTRON Spa (Campofornido), Texas-Instruments-Italy (Rieti).

Luxemburg (1)

*Public Laboratories* (1) : Institute of Technology Luxembourg

The Netherlands (11)

*Public laboratories* (10) : Institute of Phonetics (Utrecht, Groningen, Amsterdam, Nijmegen), Max-Planck Institute Gesellschaft of Nijmegen (Psychoacoustics Department), Technological University of Delft, Technological University of Twente, Institute for Perception TNO (Soesterberg), Institute for Perception Research IPO (Eindhoven), PTT Dr Neher Laboratory (Leidschendam).

*Industrial Research and Development laboratories* (1) : Philips Laboratory (Eindhoven)

Norway (3)

*Public Laboratories* (2) : Norwegian Institute of Technology (Division of Telecommunication, Trondheim), ELAB (Trondheim)

*Industrial Research and Development laboratories* (1) : Elektrisk Bureau Communications (Nesbru)

Portugal (1)

*Public Laboratories* (1) : Superior Technical Institute (Signal Analysis and Processing Laboratory) (INESC, Lisbon)

Spain (9)

*Public Laboratories* (7) : University of Madrid (ETSI (Electronics and Telecommunications, Digital Systems, Signal Theory and Processing Departments), University of Granada, Polytechnic University of Barcelona (ETSI), CSIC (Signal Processing Group, Madrid), University of Santiago (Physics Department).

*Industrial Research and Development laboratories* (2) : Standard Electrica (Madrid), Telefonica (Madrid)

Sweden (10)

*Public Laboratories (6)* : Royal Institute of Technology (KTH, Stockholm), University of Stockholm (Department of Linguistics), Chalmers University (Information Theory Division), Uppsala University (Phonetic Department), Linköping University, Swedish Telecom Administration (Stockholm)  
*Industrial Research and Development laboratories (4)* : Fonema, Infovox AB, ERICSSON Radio Systems, ELLEMTTEL Telecommunications System Lab (Alvsjö), SRA Communications.

Switzerland (6)

*Public laboratories (4)* : Federal Institute of Technology (Lausanne, Laboratory of Electromagnetism and Acoustics) and University of Lausanne (Department of Physiology), University of Neuchâtel (Microtechnical Institute), Federal Institute of Technology (Electrical Engineering Department, Zurich).

*Industrial Research and Development laboratories (2)* : ASULAB, Autophon AG.

United Kingdom (64)

*Public Laboratories (38)* : University of Birmingham, University of Bristol, University of Cambridge (Engineering Department, Department of Linguistics), Dundee University, University of Edinburgh (Center for Speech Technology Research), University of Essex (Center for Cognitive Science, Colchester), University of Hull, University of Keele, University of Lancaster, University of Leeds (Phonetic Institute), Leicester Polytechnic, University College of London (Phonetic Institute), Polytechnic Central London (School of Engineering and Sciences), Imperial College of Science and Technology (London), Loughborough University, University of Manchester (UMIST), University of Nottingham, University of Oxford, Queen's University (Belfast), University of Sheffield (Computer Science Department), University of Southampton (Electrical and Information Engineering Dept), Institute of sound and vibration Research (Southampton), University of Surrey, University of Sussex (Brighton), University College of Swansea, University of Ulster, University College of North Wales, UWIST, University of York, MRC Institute of Hearing Research, MRC Applied Psychology Unit (Cambridge).

RSRE (Malvern, SRU), NPL (Computer Science Division), RAE (Bedford, Farnborough), Royal Military College of Science, Hydrographic Department of the Ministry of Defence (Navy) (Taunton), HUSAT Research Center (Loughborough), RAF Institute of Aviation Medicine (Farnborough).

*Industrial Research and Development laboratories (26)* : Logica (Cambridge), British Telecom Research Lab (Ipswich), ICL (Reading), Marconi MSRS (Portsmouth), Marconi Avionics, Plessey, Shell-UK, Costronics, IBM-UK (Winchester), Triangle Digital Services Ltd, Voice Systems International Ltd (Cambridge), Ferranti (Bracknell), GEC Research Ltd, BTG (British Technology Group), PA Technology, Smiths Industries (Cheltenham), Racal, ACORN (Cambridge), Loughborough Sound Images Ltd, MITEL Telecom Ltd (Newport), Philips-UK, ITT Europe ESC-RC, Texas Instruments Ltd-UK, British Maritime Technology (BMT, Tyne & Wear), ACT (Apricot Computers), STC Technology Ltd.

**European Speech Products**

We will now present some speech recognition and text-to-speech synthesis products. As the market fluctuates very quickly, products or prices may have changed, and some new systems may not appear. We apologize for missing, or wrong information, and invite the reader to contact the companies for more information. Speech coding systems are not included in this survey.

### Recognition

COMPANY	PRODUCT	PRICE	WORDS	DETAILS
AEG (FRG)	ADES II		230 max.	with 2 floppy disks, speech restitution (SPRAUS) Connected word recognition (preliminary)
	ADES III			
ASULAB (Switz.)	Voice Recognition Chip		15	single chip recognition on a watch
BTG (UK)	ASR	proto	64 act.	Recognition Box developed by PA Technology under BTG sponsorship. Markov Approach (RSRE)
COMPUTER GESELLSCHAFT KONSTANZ mbh (FRG)	CSE1200		500 by 32	isolated word reco. rack Connected word version under development
	CSE1050		330	THRESHOLD systems
	CSE1060		250	imported in West Germany
	CSE1068			
GSP (FRG)	ES-85	DM4450	120	Single EuroCard Format isolated word recognition with NEC MPD 7762 VLSI Same, but whole system Speech Dialog System with ES-85 recognition card and AS85 speech Output
	SPC			
	GE85 DEAS	DM5950 DM7965		
INFOVOX (SWEDEN)	RA101		48	RS232 serial connection with MOTOROLA 68000 and NEC 7720
	RA101:PC			version for IBM PC
Loughborough Sound Images Ltd (UK)	MPD7763/4 PC Card			Speech Recognition and synthesis on a card with NEC chip set and NEC7720 based phonetic synthesis
LOGICA (UK)	LOGOS			continuous word recognition system
	LOGOS II			same on 2 boards (under study)
MARCONI (UK)	SR 128	\$15000	240	connected word recognition system
	MACROSPEAK		160- 640	possibility of creating command macros
SEL (FRG)	Voice Dialer			Telephone Voice Dialing
SPEECH DESIGN GMBH (FRG)	SPRACHER- KENNUNGS BOARD SDR600		128	isolated word reco. board with NEC MPD 7762 VLSI

STAC (FRG)	CetisSE/V24		128	isolated word reco. board with NEC chip set
ULTRATRONIK	UVRS-X		128	isolated word reco. board with NEC chip set
VECSYS (FRANCE)	RMI88	\$1800	100	multibus format recognition board
	RMI50	FF4500	50- 100	simple Europe format recognition board
	RME186	FF30000	300	continuous speech Multibus format recognition board
	TLV02			speech terminal including recognition and synthesis
	MPCD			Connected words DTW VLSI (preliminary)
XCOM (FRANCE)	SERAPHINE	FF30000		connected word recognition board multibus format

#### Text-to-Speech Synthesis

COMPANY	PRODUCT	PRICE	DETAILS
AEG (FRG)	SPRAUS		Text-to-speech synthesis in German (with VOTRAX synthesizer)
COSTRONICS (UK)	Micro- speech	\$875	Text-to-Speech synthesis in English (Formant synthesis)
EDICIEL (France)	Porte-Parole		Card and Software for Apple II (French)
EUROKA OY (Finland)	Synthe II		Phoneme Synthesis (4 boards)
FERMA (France)	F5000A	FF12500	Text-to-speech synthesis (French) Connection with telephone network
INFOVOX (Sweden)	SA101		Multilingual Synthesis system (English, German, French, Spanish, Italian, Swedish, Norwegian...) Includes LoudSpeaker
	SA101PC		Same for IBM-PC or Compatible
PHILIPS (Nether.)			Formant Synthesis based on the MEA8000 VLSI
VECSYS (France)	ICO85	\$1000	Text-to-speech Single Board. Multibus Format (French)
	SYMPA	\$500	Text-to-speech system. Includes loudspeaker. RS232 link.(French)
XCOM (France)	CPS100	\$1000	Text-to-speech single board, S100 Format (French)

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