IEEE 1979 Frontiers of Engineering in Health Care

OCTOBER 6-7, 1979

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IEEE/ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY FIRST ANNUAL CONFERENCE

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ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY

OFFICE OF THE PRESIDENT
Eli Fromm, Ph. D.

PLEASE REPLY TO:
Biomedical Engineering & Science Program
Drexel University
Philadelphia, PA 19104
(215) 895-2217

MESSAGE FROM THE PRESIDENT OF THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY

A national and international conference is the highlight of the year's activities of a technical professional society. It is especially so this year for the IEEE Engineering in Medicine and Biology Society since it marks the first of an anticipated annual event. As the organizers and sponsor of this conference we have endeavored to have it serve as a focal point. Our technical committees, publications editors and members of the administrative committee have planned together to bring you presentations at the frontiers of both research and the clinical/industrial applications. Key people have been invited to organize the sessions with both invited and contributed papers. Tutorials and workshops have been included within the regular conference program making it a very full two days. Full papers are published in the Conference Proceedings and preview abstracts of each paper are to appear in the September (pre-conference) issue of the IEEE Transactions on Biomedical Engineering.

Having first expressed the need for our Society to have an annual technical focal point when I first had the priviledge of becoming a member of the executive committee in 1973, it is a gratifying moment to see what we then began as an annual small business meeting evolve into a full technical forum. We owe much gratitude to those who labored to bring this program together in a manner designed to offer the attendee maximum technical benefit and interaction.

Welcome to our conference, enjoy, learn and reap the benefits of interaction with colleagues as a participant in this giant step of technical focus of our Society.

Eli Fromm, Ph.D.
President

From the Program Chairman

The primary purpose in organizing the Frontiers of Engineering in Health Care Conference is to better serve the changing needs of the IEEE/Engineering in Medicine and Biology Society. This annual conference offers participants the opportunity to engage actively in a common forum advancing the frontiers of engineering in health care. The opportunity is provided for all groups involved to present the state-of-the-art in biomedical engineering technology and to discuss the safe and effective use and management of medical devices. This interaction will allow all specialty groups and professionals in the health care community to communicate more effectively to advance biomedical research and to improve patient care.

Technical sessions, tutorials and workshops including selected and invited presentations have been obtained, and a special effort has been made to select session chairpersons who will work in developing their sessions so that only the most relevant topics will be presented. Key papers have been invited for all sessions.

All papers presented are supplemented by a published abstract and a full paper. An abstract of each paper will be published in the EMBS Transactions, and the full paper will be published following peer review in the Conference Proceedings for this conference.

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IEEE Engineering in Medicine and Biology Society

The Engineering in Medicine and Biology Society of the IEEE (IEEE/EMBS) is an association of 7,000 members concerned with the application of engineering science and methodology to biology, medicine, and health care delivery systems.

EMBS is a Society within the umbrella framework of the Institute of Electrical and Electronics Engineers (IEEE) offering identification with the world's largest professional engineering organization of 180,000 members. Activities of the IEEE/EMBS include:

Publications - The IEEE Transactions on Biomedical Engineering is a monthly publication of reviewed articles reporting original research and application and development, short communications to disclose new ideas, and tutorials and reviews. The EMBS Newsletter is published quarterly and contains news and events of current interest to biomedical engineering professionals.

Conferences - Conference Proceedings are widely distributed and indexed through IEEE and may be purchased at member's prices from IEEE. The Society also cosponsors and/or cooperates in other national and regional biomedical conferences.

Technical and Professional Committees - EMBS Committees organize conference sessions, workshops and special activities on behalf of the Society. Technical Committees include: bioelectric phenomena, clinical engineering, medical instrumentation, prosthetic and sensory aids, signal processing and information handling, transducers and devices, and biomaterials. Professional Committees include: awards, biomedical coordination, education, ethics, membership, professional activities, publications, standards, government affairs, and industrial relations. In addition, EMBS participates, through appointed delegates, in other national bodies such as ANSI and NFPA as well as in broad based IEEE Technical Committees addressing such issues as energy, ocean engineering, environmental quality, man and radiation, and social implications of technology.

Regional Councils and Chapters - Society members have the opportunity to exchange technical and professional information with colleagues in their same geographic area through meetings and activities of 7 EMBS Regional Councils and 33 Chapters. Membership in these geographically organized subdivisions is an automatic component of Society Membership.

Membership in IEEE/EMBS is open to all qualified persons in grades designated student, senior member, fellow, and affiliate. Biomedical professionals who wish to join EMBS but not join the IEEE umbrella organization may do so as affiliate members of EMBS. Affiliate members are accorded the opportunities of participation in all EMBS programs and activities as planned and administered by the EMBS elected Administrative Committee (AdCom).

SATURDAY, OCT. 6

Tutorials & Workshops 7:30 AM–9 AM	Morning Technical Session 9 AM–Noon	Lunch Break Noon–1:30 PM	Afternoon Technical Session 1:30 PM–4:30 PM	Tutorials & Workshops 8 PM–10 PM	Room
	Session 1 Signal Processing and Imaging Part 1		Session 5 Signal Processing and Imaging Part 2 - - - - - - - - - - - Session 6 Computers in Medicine	Microprocessors and Instrumentation	Silver Room
	Session 2 Biopotential and Biochemical Instrumentation		Session 7 Clinical Engineering	Pending Changes in the National Electrical Code and its Impact on Health Care	Denver Room
	Session 3 Non-Invasive Diagnostic Technology Part 1		Session 8 Non-Invasive Diagnostic Technology Part 2	Introduction to I.C. Technology and its Applications	Century Room
	Session 4 Standards				Spruce Room

SUNDAY, OCT. 7

Tutorials & Workshops 7:30 AM–9 AM	Morning Technical Session 9 AM–Noon	Lunch Break Noon–1:30 PM	Afternoon Technical Session 1:30 PM–4:30 PM	Tutorials & Workshops 8 PM–10 PM	Room
Computers in the Practice of Medicine	Session 9 Biomechanical Instrumentation	Keynote Address Dr. Seymour Perry National Center for Health Care Technology	Session 13 Computerized Control of Therapy - - - - - - - - - - - Session 14 General Principles of Biomed. Engr.	BME Program Directors Meeting	Silver Room
Delivery of Rehabilitation Services	Session 10 Devices for the Disabled Part 1	(See Announcements for Luncheon Room Assignment)	Session 15 Devices for the Disabled Part 2 - - - - - - - - - - - Session 16 Education	ECG Data Reduction Algorithms for Microprocessors	Denver Room
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LIST OF KEY WORDS

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TUTORIALS/WORKSHOPS

Workshops and Tutorials are summarized at the end of the Conference Proceedings.

STATISTICAL PATTERN RECOGNITION OF BALLISTOCARDIOGRAMS

R.Hanka Ph.D.
School of Clinical Medicine
University of Cambridge
England

Summary.

An application of statistical pattern recognition techniques to the analysis of ballistocardiograms is described. The data consisted of 131 recordings which were divided into two groups (normal, pathological). The discriminatory potential of the individual waves of the ballistocardiogram was assessed by standard feature selection techniques. The results of the analysis confirm most of the clinical views and also offer some new information about the importance of the individual peaks of the ballistocardiogram for correct diagnosis. The overall performance of the constrained hyperquadric classifier was very encouraging. Using an optimal subset of features the classification error was lower than 4%.

Introduction.

Ballistocardiography (BCG) is a technique of graphic representation of the movements of the body caused by the ballistic forces associated with cardiac contraction and ejection of blood and with the subsequent deceleration of blood flow through the large vessels.

Although it is accepted that ballisto-cardiography can give valuable information about the heart which is otherwise difficult to obtain, the technique has not yet found wider use. The complexity of the BCG waveform together with its rather subjective interpretation are perhaps the main reasons behind its relative unpopularity.

Pattern recognition techniques were used in this study to throw some objective light on the significance of individual features of a BCG waveform and to clarify their importance for efficient diagnosis.

Method.

The data consisted of 10 seconds long simultaneous recordings of ballistocardiograms and electrocardiograms. It is a standard practice to begin each BCG on the peak of the QRS complex of the ECG and this method was used in this study. The ECG records were scanned by the computer for the QRS complexes and the BCG signals coresponding to the individual cardiac cycles were then extracted into records of a fixed number of samples, in our case 100, of variable sampling frequency. Altogether there were 131 ballisto-cardiograms which were divided into two groups. Normal and abnormal consisting of 81 and 50 records respectively.

The normal ballistocardiogram is essentially a series of consecutive waves, named H,I,J,K,L,M,N,O, forming a distinctive pattern (Fig. 1). The upward waves, H,J,L,N, represent

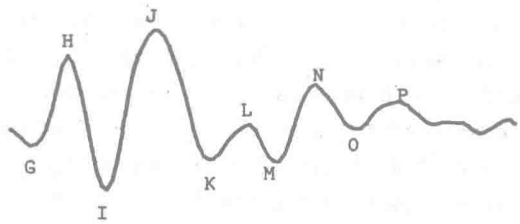

Fig. 1.

headward impacts or recoils of the body, whereas the downward waves I,K,M,O, represent footward movements. The waves H,I,J,K, occur during the systole while the waves L M,N,O, are diastolic. Preceding the H wave could be a group of smaller waves F and G associated with the ballistic effects of atrial systole. The H wave itself coincides with isometric contraction and may be due to headward motion of both atrioventricular septum and the blood in the atria. The I is a deep, downward wave and the J a prominent, upward wave, both occurring during ventricular ejection.

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The J wave is usually the most prominent wave of the ballistocardiogram and is caused by the impact of blood on the arch of the aorta and the bifurcation of the main pulmonary artery.

The K wave occurs just before the second heart sound and is attributed to deceleration of blood flow in the aorta. The L,M,N, and other waves occur in diastole and are normally much less prominent than the systolic waves.

<u>Deterministic representation of BCG waveform.</u>

The diagnostic parameters of the BCG trace which are recognised by physicians were evaluated first. A physician would base his classification of a BCG record on the absence or existence of individual peaks, on their amplitude, and to a certain degree, on their relationship in time.

A similar approach was adopted for computer classification. A computer program identifying and extracting amplitudes of the ten standard peaks (G to P see Fig.1.) was used to form a set of ten-dimensional pattern vectors.

All available data consisting of 131 such vectors were then used for feature extraction. The importance of individual features was assessed by calculating the Mahalanobis distance (D^2), which is both statistically robust and computationally relatively simple. The results are in Fig.2. It appears that the two most important features are the amplitudes of the peaks H and O. The H wave is due to the headward motion of the atrioventricular septum and of the blood in atria and it is known that increased amplitude of this wave is observed with myocardial disease and heart failure and in cases of hypertension. The wave O is one of the diastolic waves and no particular importance has so far been attributed to it.

Waves H and O are, in the order of decreasing D^2, followed by waves G,N,K and M. Of these only the K wave is recognised as having some diagnostic importance. Its amplitude is known to increase when there is an increased peripheral resistance as in essential hypertension or arteriosclerosis.

It is very surprising that the waves I and J which are generally believed to contain most of

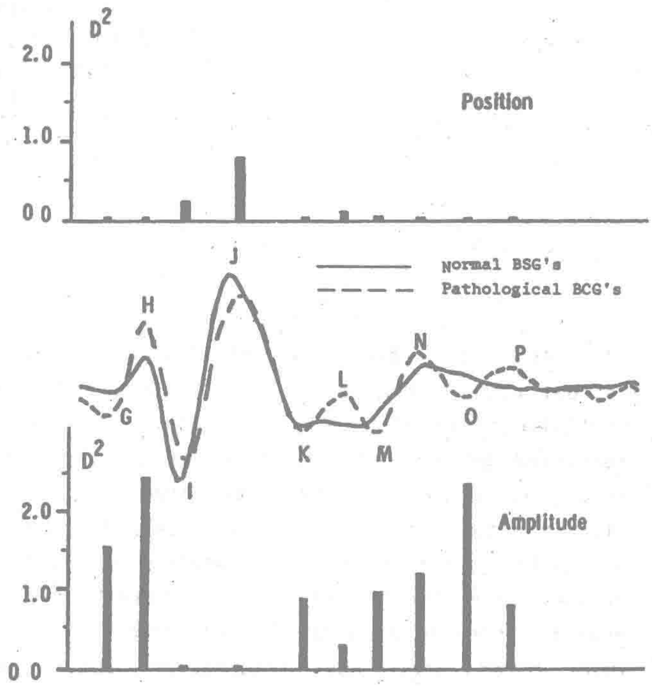

Fig. 2.

the diagnostic information have received the lowest ranking on the part which their amplitudes play in efficient classification.

An explanation of this paradox may be in the tact that so far we have been considering only the amplitudes of the individual peaks without any regard to their position. This was confirmed when the positions of the peaks were also taken into account. The results of the analysis are given on the lower half of Fig.2 where are drawn the Mahalanobis distances coresponding to the positions of the peaks.

It would appear that the only important differences in the timing of the individual peaks are in the positions of the waves I and J which obtained the lowest ranking on the D^2 of their amplitudes. The positions of other peaks seem to have minimal discriminatory potential when compared with that of their amplitudes.Each of the ten peaks was therefore represented by its amplitude with the exception of the waves I and J which were represented by their positions. The best subsets (in terms of D^2) were then evaluated starting with one and finishing with all ten features giving the following result