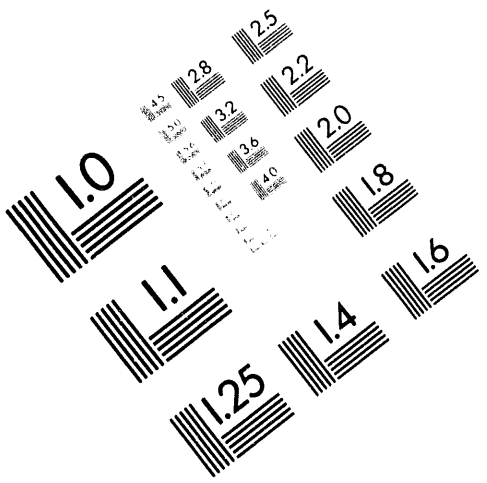

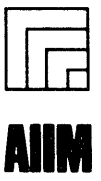

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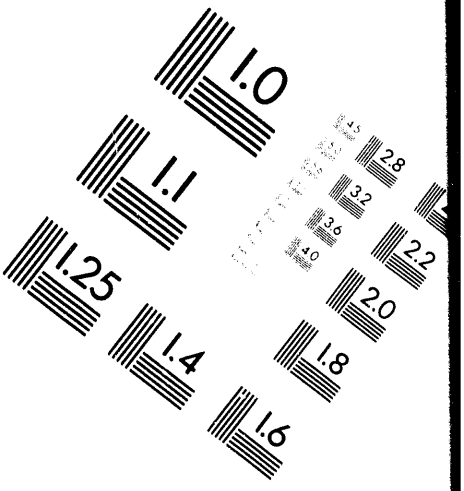

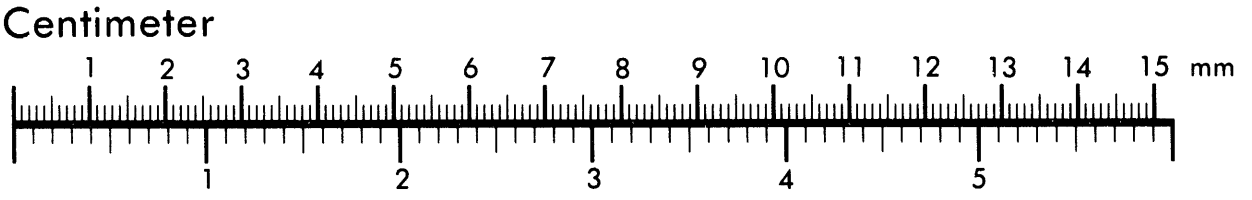

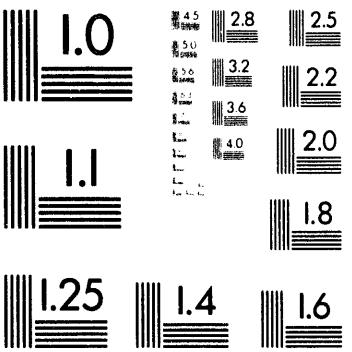

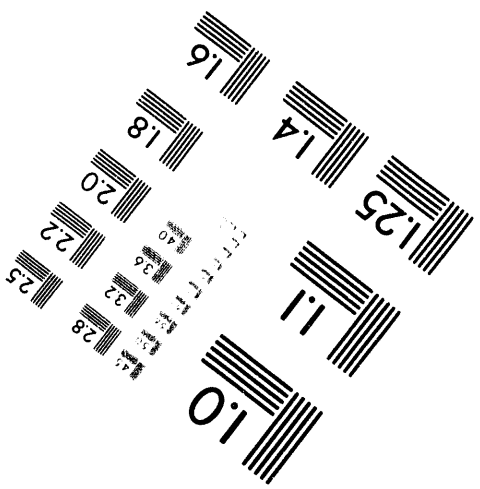

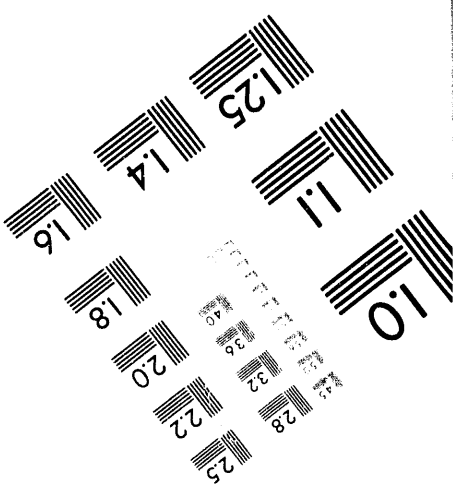

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ARTIFICIAL NEURAL NETWORKS IN MEDICINE

P. E. Keller

Handout/Technology Brief

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Pacific Northwest Laboratory
Richland, Washington 99352

Technology Brief

Artificial Neural Networks in Medicine

Pacific Northwest Laboratory
Operated by Battelle Memorial Institute for the U.S. Department of Energy

What Is an Artificial Neural Network?

An artificial neural network (ANN) is an information processing paradigm that was inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well.

When Are Artificial Neural Networks Used?

ANNs have been applied to an increasing number of world problems of considerable complexity. Their most important advantage is in solving problems that are too complex for conventional technologies – problems that do not have an algorithmic solution or for which an algorithmic solution is too complex to be found. In general, because of their abstraction from the biological brain, ANNs are well suited to problems that people are good at solving but computers are not. These problems include pattern recognition and forecasting (which requires the recognition of trends in data). However, unlike the human capability in pattern recognition, the ANN's capability is not affected by factors such as fatigue, working conditions, emotional state, and compensation.

Benefits

The ANN approach to medical information processing has several benefits.

- It is trained by examples instead of rules.
- It is automated.
- It eliminates issues associated with human fatigue and habituation.
- It enables rapid identification.
- It enables analysis of conditions and diagnosis in real time.

When Can Artificial Neural Networks Be Applied to Medicine?

The ANN approach to the analysis of data will see extensive application to biomedical problems in the next few years. It has already been successfully applied to various areas of medicine, such as diagnostic aides, biochemical analysis, image analysis, and drug development.

Medical Diagnostic Aides

The application of ANNs in diagnosing heart attacks received publicity in the *Wall Street Journal* when the ANN was able to diagnose with better accuracy than physicians. This application is significant because it was used in the emergency room where the physicians are not able to handle large amounts of data.

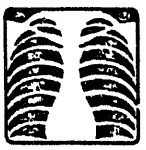
A commercial product employs ANN technology in the diagnosis of cervical cancer by examining pap smears. In clinical use, this product has proven to be superior over human diagnosis of pap smears.

In the United Kingdom, an ANN used in the early diagnosis of myocardial infarction is currently undergoing clinical testing at four hospitals. At the research level, ANNs are used in diagnosing ailments such as heart murmur, coronary artery disease, lung disease, and epilepsy.

This technology is also being used in the interpretation of electrocardiograms (ECG) and electroencephalograms (EEG).

Biochemical Analysis

ANNs are used in a wide variety of analytical chemistry applications. In medicine, ANNs have been used to analyze blood and urine samples, track glucose levels in diabetics, determine ion levels in body fluids, and detect pathological conditions such as tuberculosis. At Pacific Northwest Laboratory, ANNs are being combined with chemical sensor arrays and spectrometers for use in automated chemical analysis.



Medical Image Analysis

ANNs are used in the analysis of medical images from a variety of imaging modalities. Applications in this area include tumor detection in ultra-sonograms, detection and classification of microcalcifications in mammograms, classification of chest x-rays, tissue and vessel classification in magnetic resonance images (MRI), x-ray spectral reconstruction, determination of skeletal age from x-ray images, and determination of brain maturation. At Pacific Northwest Laboratory, ANNs are being developed to examine thallium scintigram images of the heart and identify the existence of infarctions. Another project at Pacific Northwest Laboratory uses ANN technology to aid in the visualization of three-dimensional ultrasonic images.

Drug Development

Researchers at the National Institutes of Health as well as other institutions have used ANNs as tools in the development of drugs for treating cancer and AIDS. ANNs are also used in the process of modeling biomolecules. At Pacific Northwest Laboratory, ANN technology is being incorporated into the software used to model protein molecules.

Resources

Information on ANN developments at Pacific Northwest Laboratory is available in the Mosaic pages of the Molecular Science Research Center (http://www.msrc.pnl.gov:2080/docs/cie/neural.homepage.html).

Those wishing further information on ANN technology and potential applications of ANNs to medicine are encouraged to contact Pacific Northwest Laboratory.

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