Information Sciences

▶ Processing Electromyographic Signals To Recognize Words

The speaker need not make any sound.

Ames Research Center, Moffett Field, California

A recently invented speech-recognition method applies to words that are articulated by means of the tongue and throat muscles but are otherwise not voiced or, at most, are spoken *sotto voce.* This method could satisfy a need for speech recognition under circumstances in which normal audible speech is difficult, poses a hazard, is disturbing to listeners, or compromises privacy. The method could also be used to augment traditional speech recognition by providing an additional source of information about articulator activity. The method can be characterized as intermediate between (1) conventional speech recognition through processing of voice sounds and (2) a method, not yet developed, of processing electroencephalographic signals to extract unspoken words directly from thoughts.

This method involves computational processing of digitized electromyographic (EMG) signals from muscle innervation acquired by surface electrodes under a subject's chin near the tongue and on the side of the subject's throat near the larynx (see figure). After preprocessing, digitization, and feature extraction, EMG signals are processed by a neural-network pattern classifier, implemented in software, that performs the bulk of the recognition task as described below.

Before processing signals representing words that one seeks to recognize, the neural network must be trained. During training, EMG signals representing known words and/or phrases are first sampled over specified time intervals (each typically about 2 seconds long). The portions of the signals recorded during each time interval are denoted sub-audible muscle patterns (SAMPs). Sequences of samples of SAMPs for overlapping time intervals are processed by a suitable signal-processing transform (SPT), which could be, for example, a Fourier, Hartley, or wavelet transform. The SPT outputs are entered into a matrix of coefficients, which is then decomposed into contiguous, non-overlapping two-dimensional cells of entries, each cell corresponding to a feature. Neural-network analysis is performed to esti-
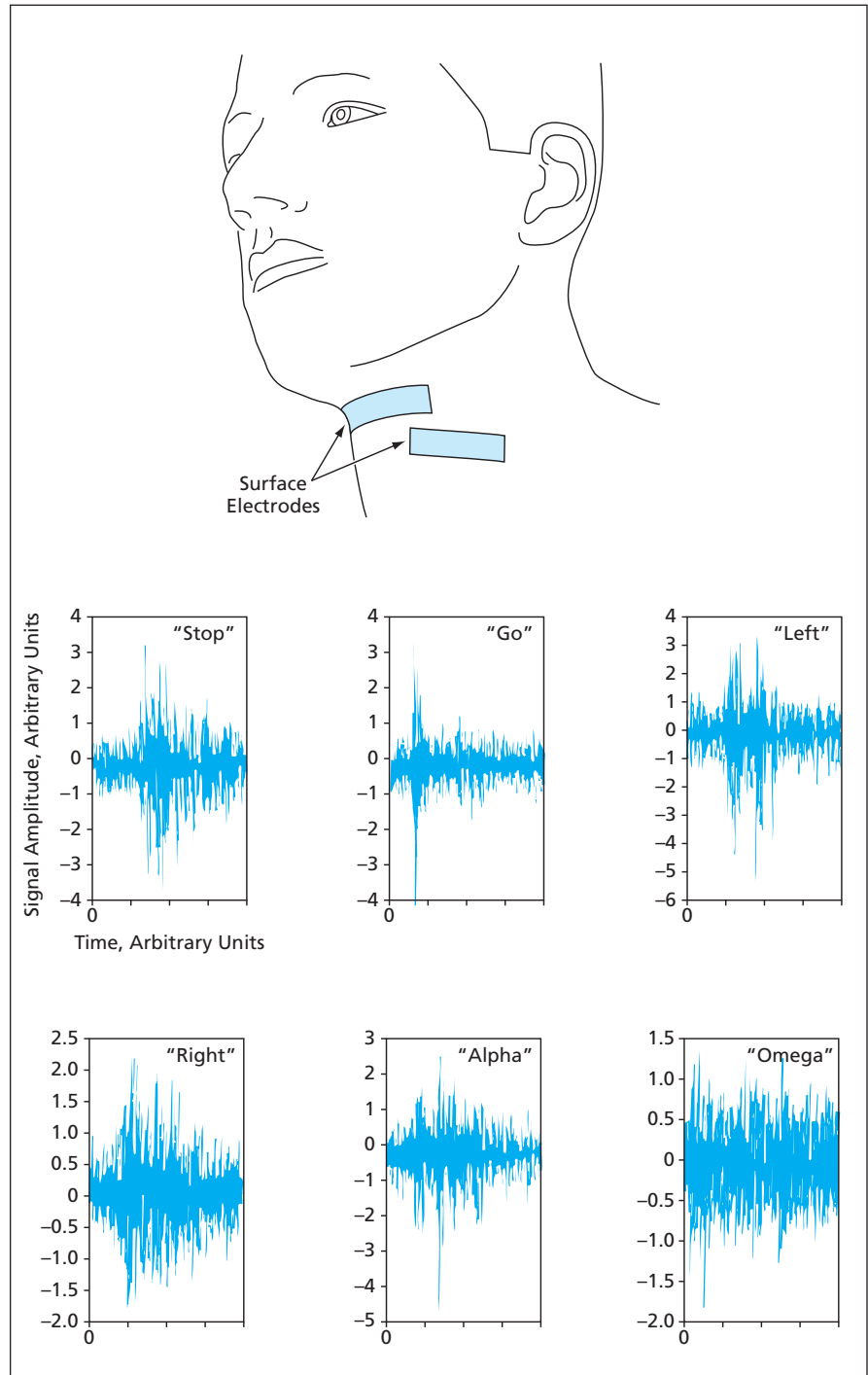
Surface Electrodes Under and Near the Chin acquire signals indicative of tongue and throat muscle activity during articulation of words, even when the words are unvoiced. The signals are then processed to recognize the words. The six signal samples shown here correspond to the noted words.

mate reference sets of weight coefficients for weighted sums of the SAMP features that correspond to known words and/or phrases.

Once training has been done, a SAMP that includes an unknown word is sampled and processed by the SPT, the SPT outputs are used to construct a matrix, the matrix is decomposed into cells, and

neural-network analysis is performed, all in the same manner as that of training. The weight coefficients computed during training are used to determine whether there is a sufficiently close match between an unknown word in the SAMP and a known word in the training database. If such a match is found, the word is deemed to be recognized.

Physical Principle for Generation of Randomness

NASA's Jet Propulsion Laboratory, Pasadena, California

A physical principle (more precisely, a principle that incorporates mathematical models used in physics) has been conceived as the basis of a method of generating randomness in Monte Carlo simulations. The principle eliminates the need for conventional random-number generators.

The Monte Carlo simulation method is among the most powerful computational methods for solving high-dimensional problems in physics, chemistry, economics, and information processing. The Monte Carlo simulation method is especially effective for solv-

ing problems in which computational complexity increases exponentially with dimensionality. The main advantage of the Monte Carlo simulation method over other methods is that the demand on computational resources becomes independent of dimensionality. As augmented by the present principle, the Monte Carlo simulation method becomes an even more powerful computational method that is especially useful for solving problems associated with dynamics of fluids, planning, scheduling, and combinatorial optimization.

The present principle is based on coupling of dynamical equations with the corresponding Liouville equation. The randomness is generated by non-Lipschitz instability of dynamics triggered and controlled by feedback from the Liouville equation. (In non-Lipschitz dynamics, the derivatives of solutions of the dynamical equations are not required to be bounded.)

DSN Beowulf Cluster-Based VLBI Correlator

Software architecture is scalable to meet faster processing needs for future data processing.

NASA's Jet Propulsion Laboratory, Pasadena, California

The NASA Deep Space Network (DSN) requires a broadband VLBI (very long baseline interferometry) correlator to process data routinely taken as part of the VLBI source Catalogue Maintenance and Enhancement task (CAT M&E) and the Time and Earth Motion Precision Observations task (TEMPO). The data provided by these measurements are a crucial ingredient in the formation of precision deep-space navigation models. In addition, a VLBI correlator is needed to provide support for other VLBI related activities for both internal and external customers.

The JPL VLBI Correlator (JVC) was designed, developed, and delivered to the DSN as a successor to the legacy Block II Correlator. The JVC is a full-capability VLBI correlator that uses software processes running on multiple computers to cross-correlate two-antenna broadband noise data. Components of this new system (see Figure 1)
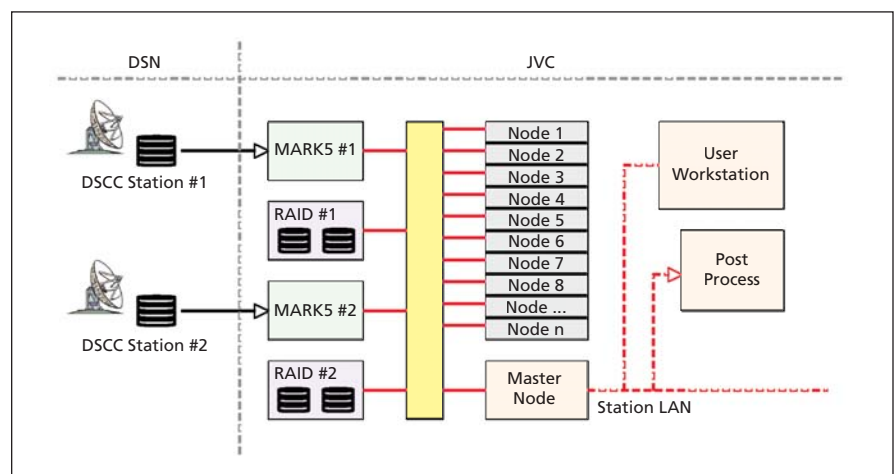

Figure 1. **Components of the New Correlator** are shown in this simplified block diagram.

consist of Linux PCs integrated into a Beowulf Cluster, an existing Mark5 data storage system, a RAID array, an existing software correlator package (SoftC) originally developed for Delta DOR

Navigation processing, and various custom-developed software processes and scripts.

Parallel processing on the JVC is achieved by assigning slave nodes of the