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ADP014019

TITLE: Alternative Speech Sensors for Military Applications

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TITLE: Multi-modal Speech Recognition Workshop 2002

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ADP014015 thru ADP014027

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Alternative Speech Sensors for Military Applications

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6/10/02



Agenda

- Overview of current sensor technologies
- Possible future technologies
- Possible sensor fusion methods
- Military requirements
- Conclusion



Possible Methods for Improved ASR in Noise

- Reduce or eliminate noise through the processing of the speech signal based on properties of the signal components
- Detect speech without detecting noise
 - Many alternative sensors have reduced signal information
- Combinations of the above
 - Specialized sensors and processing
 - Multiple speech sensors and fusion of signals



Current Sensor Technologies

- Airborne acoustic microphones
- Contact acoustic microphones
- Bone conduction microphones
- Other alternative speech sensors



Airborne Acoustic Microphones

- Handheld microphones (Shure, etc)
- Headsets (Knowles, Shure, Telex, etc)
 - Noise canceling, close talking
- Super-directional microphones (Telex, etc)
 - Narrow band through beam forming
 - Linear arrays in a reinforcing pattern



Contact Acoustic Microphones

- Throat microphones (TEA, Genesys, Temco)
 - ARL Physiological Microphone
 - 32dB noise rejection
 - Acoustic response differs from a regular microphone
- Ear microphones (Jabra, Temco)
 - Some ear microphones are bone conduction
 - See next slide



Bone Conduction Microphones

- Navy bone conduction microphone
- Ear mounted bone conduction microphone
 - Invisio (TEA)
- Top of head bone conduction (Temco)
- Tooth mounted bone conduction microphone
 - Developed through a SBIR at CECOM



Other Alternative Speech Sensors

- Glottal Electromagnetic Micropower Sensor (GEMS)
 - Developed at Lawrence Livermore Nat. Labs
 - Commercial developer Aliph
 - Uses RADAR to measure internal motion
 - Reduced bandwidth
- Lip reading system (camera/computer)
 - Provides limited information, not a speech signal
 - Robust to noise



Other Alternative Speech Sensors

- Ultrasonic lip reader
 - Uses ultrasonic sensor to measure mouth opening
 - Have not been able to locate one of these devices, but have heard of them



Possible Future Technologies

- “Camera like” sensor that detects surface skin differently than tissues in the mouth
 - Would simplify detection of voiced speech
 - 3-5 and 8-12 micron FLIRs not suitable
 - Possibly some Near-Infrared technology?
- Novel vibration sensors
 - Technology?
 - Accelerometer? RADAR?



What to Sense?

- Vibration
 - Direct reading of speech or components
 - Close connection to avoid noise
- Alternatives?
 - Measure motion of speech articulators?
 - Tongue, teeth, glottis, sinuses
 - Modern jewelry?
 - Nose ring, cheek stud (microphones)
- Other methods?



Sensor Fusion

- Combining the outputs of one or more sensors to produce an improved speech signal
- Most appropriate in noisy environments where one or more sensors can be used to attempt to capture components of the speech signal while rejecting noise



Possible Sensor Fusion Methods

- Combine signals from multiple sensors in a cooperative fashion
 - Some non-standard speech sensors capture speech data while minimizing noise, but do not detect the full bandwidth of the speech signal
 - Could extract the cleanest spectral components of each sensor for input to ASR software



Possible Sensor Fusion Methods

- Use “clean speech” from noise robust sensors to remove noise from a primary sensor (airborne microphone)
 - Difference in secondary sensor signals and primary sensor signal is the noise (in the acoustic bands covered by the secondary sensors)
 - Could use correlation to remove noise that extends beyond the signal range of the sensor



Alternative Concept

- Work to improve a non-standard speech sensor and a matched ASR system to provide an integrated speech-in-noise package
 - Need a sensor with good noise rejection and “sufficient” signal capture capability
 - Need to tune the ASR engine to the peculiarities of the alternative speech sensor



Military Requirements

- Different for each application
 - Just like in the commercial world
- Selection of domain can be used to limit the problem
 - Command and control (C2) domain
 - Vocabulary of 1-5K words
 - Typically command phrases
 - Limited perplexity



Military Requirements (II)

- Most military environments will be noisy
 - Vehicles, people, weapons, generators, aircraft ...
- Capability to use existing microphones desirable in some cases
 - Communications via radio and vehicle intercoms
 - Difficulty of replacing all field equipment with improved or multi-modal speech sensors
 - Difficulty of getting more sensors on a soldier



What Do Military Users Want?

- They want a system that:
 - Works perfectly in all conditions
 - Weighs nothing
 - Is unbreakable
 - Does not interfere with their mission
 - Produces more energy than it uses
- Field soldiers are already overloaded
 - Make systems small (hand held), or make the software portable to platforms that are already carried by the soldier



Military Domains For SR

- C2 (command and control)
 - Constrained vocabulary, limited perplexity
 - “Tongue operated keyboard”
 - Electronic map navigation, radio settings
- Form completion
 - Repetitive task, limited vocabulary
 - Field reports, logistics (ordering supplies/ammo)
 - Might be performed over a low bandwidth field radio



Military Domains For SR (II)

- Information gathering
 - Vocabulary may not be constrained
 - User may have the option to enter free text fields with observations or other comments
 - Vehicle inspection, quality control
 - An actual military application of SR technology
- Monitoring of enemy communications
 - A much larger and more difficult application
 - Not amenable to application of alternative sensors



Conclusion

- There are a wide variety of alternative speech sensors available for exploitation for SR in military applications
- While many of these sensors do not detect the full range of human speech, their intrinsic noise rejection makes them useful
- Combinations of these alternative sensors may provide good solutions for the application of speech recognition in military environments