Software for Mission

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DM18-1198

Introduction – Software for Mission

- Enabling new mission capability through advances in software
- Help bridge “innovation gap” between academic research and mission deployment

Affordable
Be Affordable such that the cost of acquisition and operations, despite increased capability, is reduced and predictable

Trustworthy
Be Trustworthy in construction, correct in implementation, and resilient in the face of operational uncertainties

Capable
Bring Capabilities that make new missions possible or improve the likelihood of success of existing ones

Timely
Be Timely so that the cadence of fielding is responsive to and anticipatory of the operational tempo of the warfighter

Enduring challenges from the SEI Technical Strategic Plan

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Machine Learning as a Key Capability Enabler

AI Stack

ai.cs.cmu.edu

- Using machine learning to allow AI systems to understand and model the world
- Climbing “semantic ladder” from perception to comprehension
- Providing autonomous capabilities to the warfighter to enhance the mission

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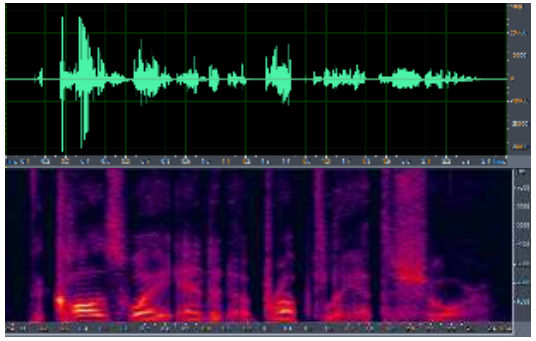
Software for Mission

- **Better understand the world**
  - Summarizing and Searching Video



- **Better understand humans**
  - Emotion Recognition from Voice

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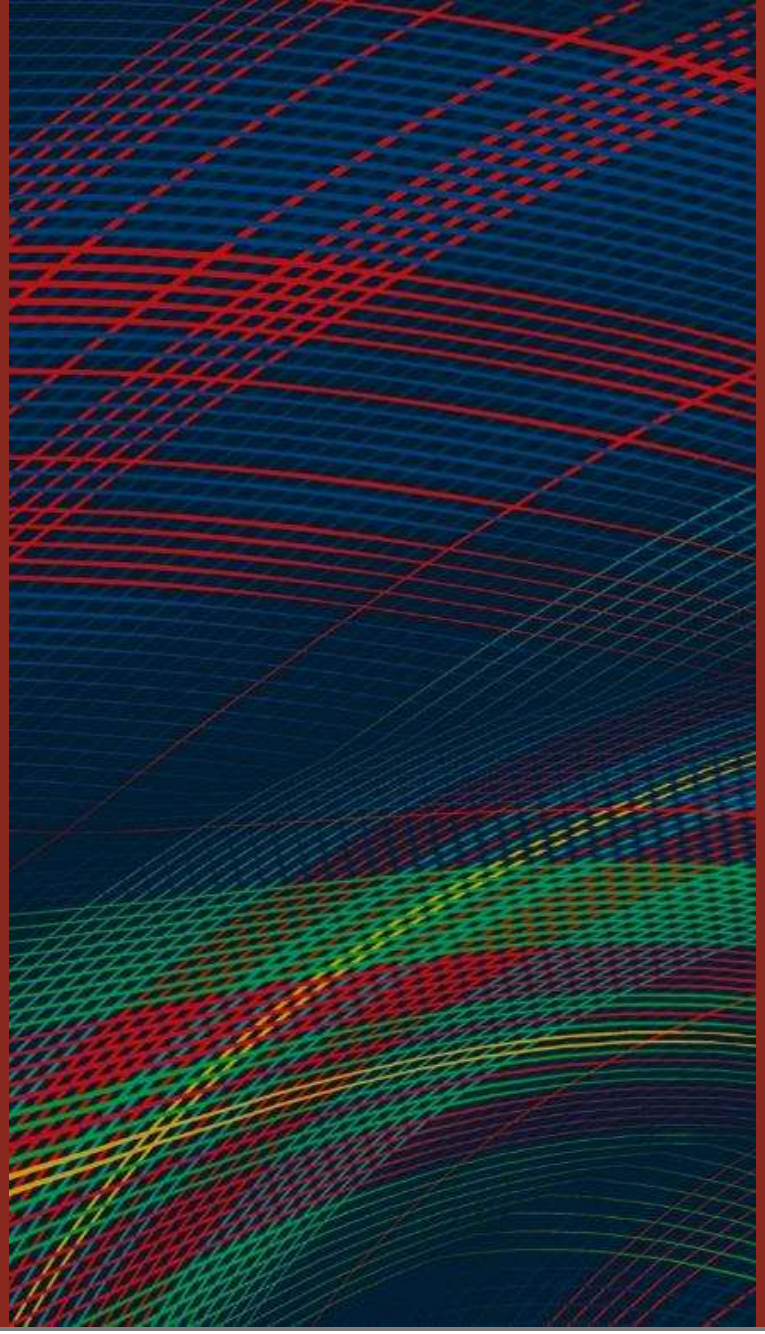
Software for Mission

Summarizing and Searching Video



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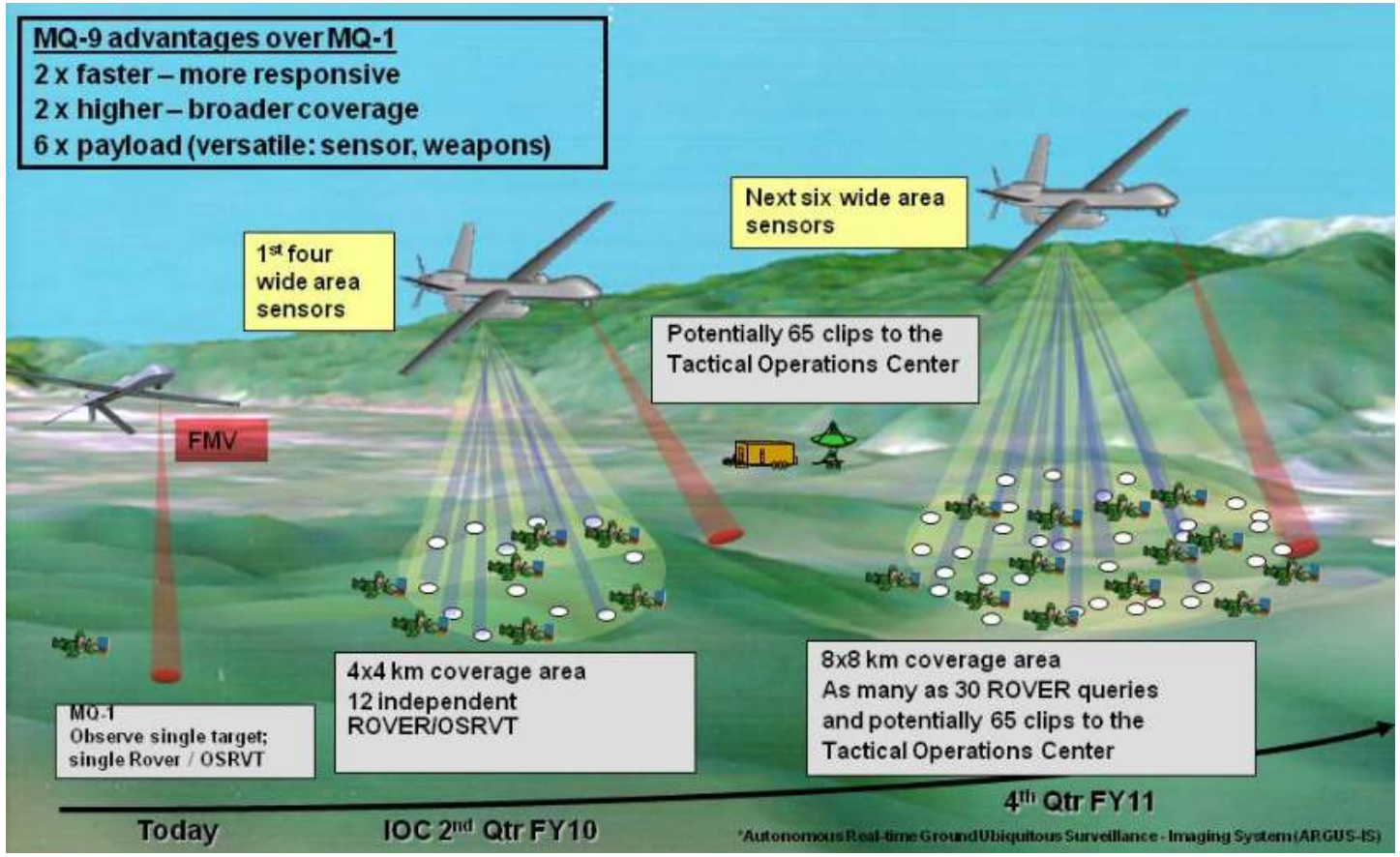
Overview – Aerial Surveillance

af.mil/News/Photos/igphoto/2000396399/

MQ-9 Reaper
afsoc.af.mil/News/Photos/igphoto/2000803531/

Increasing Capabilities

Wide Area Airborne Surveillance (WAAS)



archive.defense.gov/DODCMSShare/briefingslide/339/090723-D-6570C-039.JPG

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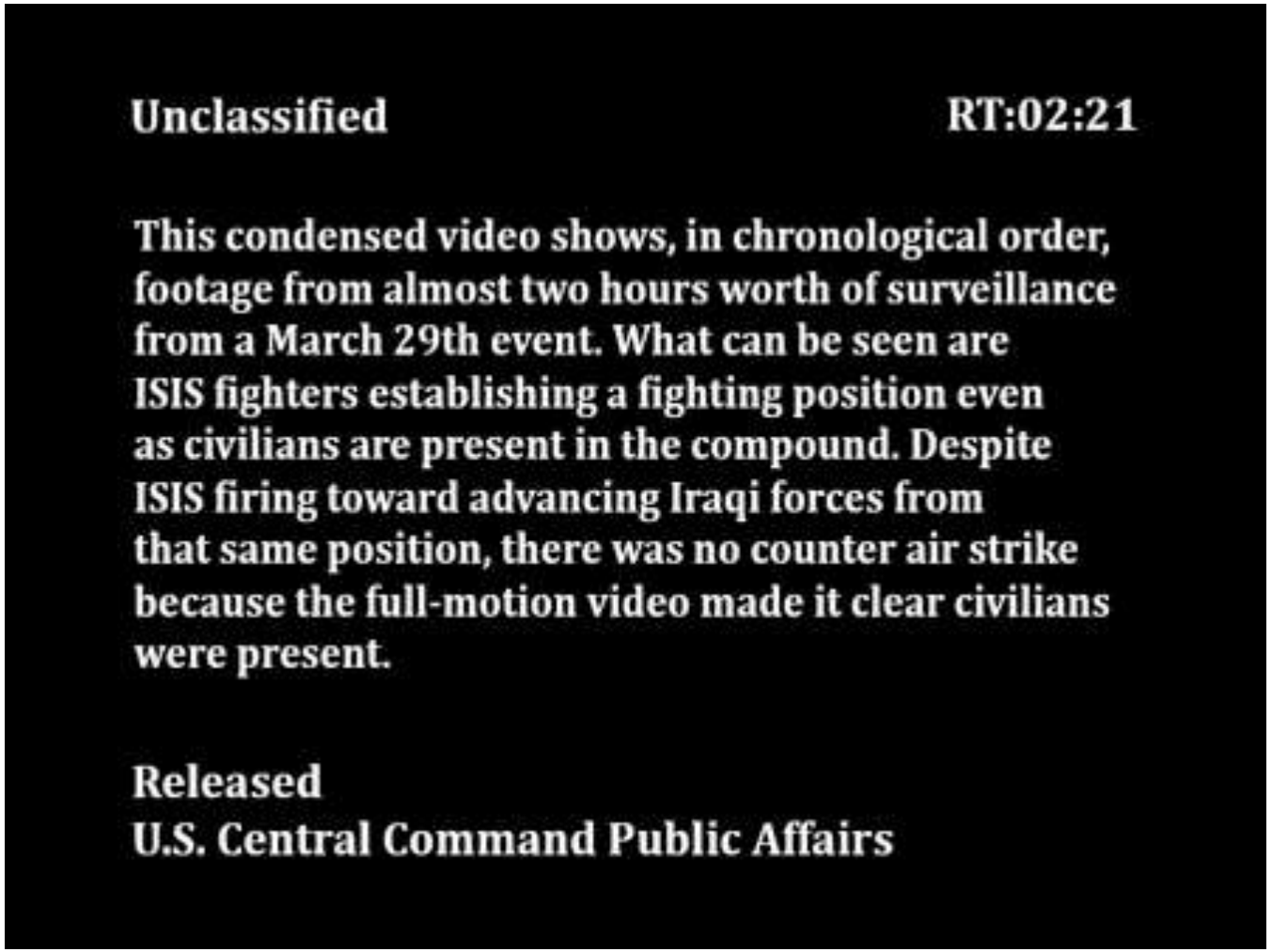
Summarizing and Searching Video



Publicly released by U.S. Central Command Public Affairs
centcom.mil/MEDIA/VIDEO-AND-IMAGERY/VIDEOS/videoid/520438/

Problem

- Volume of streaming and archived surveillance video is outpacing the ability of DoD analysts to manually monitor and view it
- Increased push in DoD to develop and deploy computer vision analytics (e.g., Project Maven) in order to reduce cognitive load on analysts and to increase productivity

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Video Summarization (2017-18)

"Protests in Baltimore, Maryland 2015, Aerial Surveillance Footage." FBI Records: The Vault.
vault.fbi.gov/protests-in-baltimore-maryland-2015/unedited-versions-of-video-surveillance-footage

Collaboration: CMU Machine Learning Department

- Eric Xing, Xiaodan Liang, and Lisa Lee
- Algorithm development support and guidance

Goal: Condense long surveillance videos into shorter summary (i.e. trailer)

Approach: Identify unique segments using

- object detection/tracking,
- segmentation, and
- LSTM autoencoders

Results:

- Potential use to triage large volume of videos
- Not suitable to support analysts in real-time

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Pattern of Life Analysis

Goal: Recognize *patterns of life* in areas of interest under aerial observation

- Utilize statistical and machine learning techniques
- Enhance situational awareness and decision speed of intelligence analysts

Aerial surveillance video

Sensor Metadata

Detect, Classify, & Georegister Objects

- People
- Vehicles
- Buildings

Object Aggregations, Interactions, & Tracks

Pattern of Life Processing

- Behaviors
- Anomalies
- Predictions

Human-machine teaming

- Alerts, tips, cues
- Summaries (products)

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Anomalous Track Detection

Simulated map area with the "ZigZag" track.

Use Case: Detecting unusual activity in compound or city overwatch missions

- Synthetic track data using SUMO* traffic simulator
- Unsupervised LSTM Autoencoder algorithm to analyze track data and detect anomalous/unusual tracks
- "ZigZag" (shown on right) is manually added to generated tracks

* http://sumo.dlr.de/index.html

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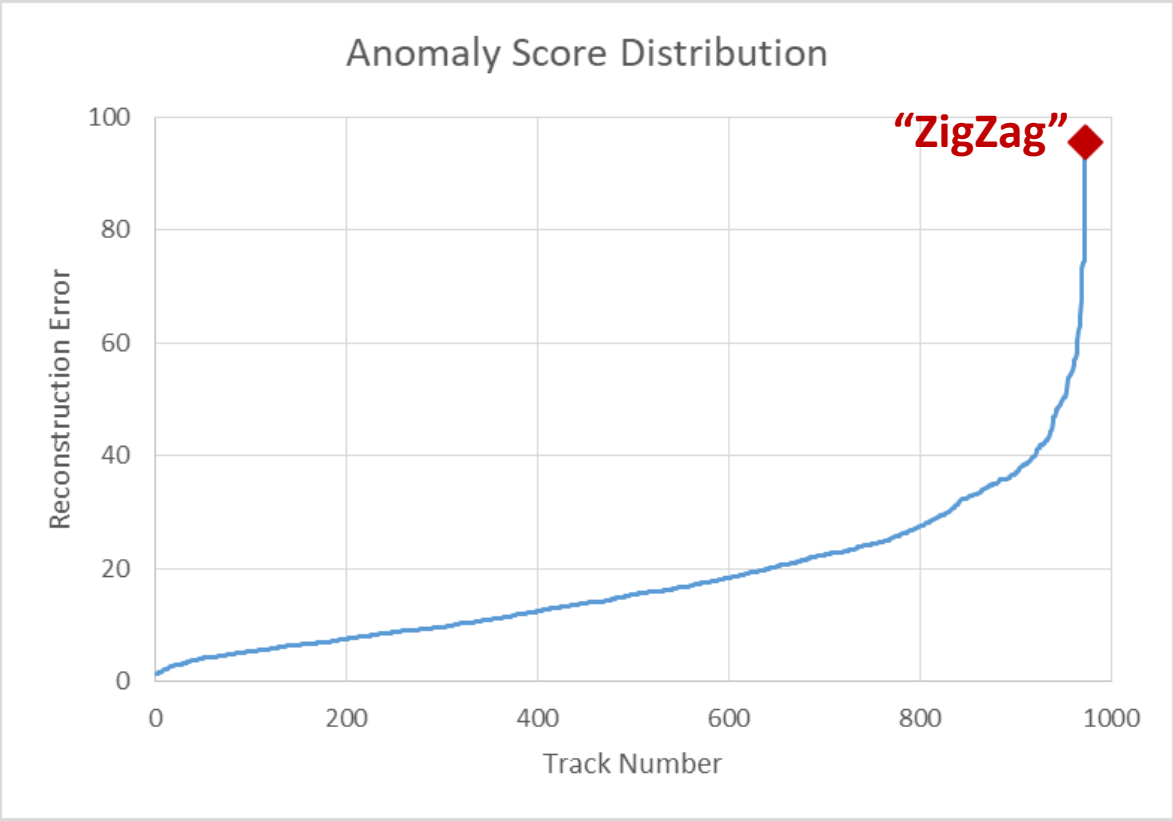
Anomalous Track Detection



Distribution of Track Anomaly Scores

Initial Results

- 974 tracks analyzed in ~15 min
- "ZigZag" had 2nd highest score
- Additional anomalies detected:
  - Vehicle with long delays (traffic jams) at multiple intersections
  - Vehicle making a U-turn

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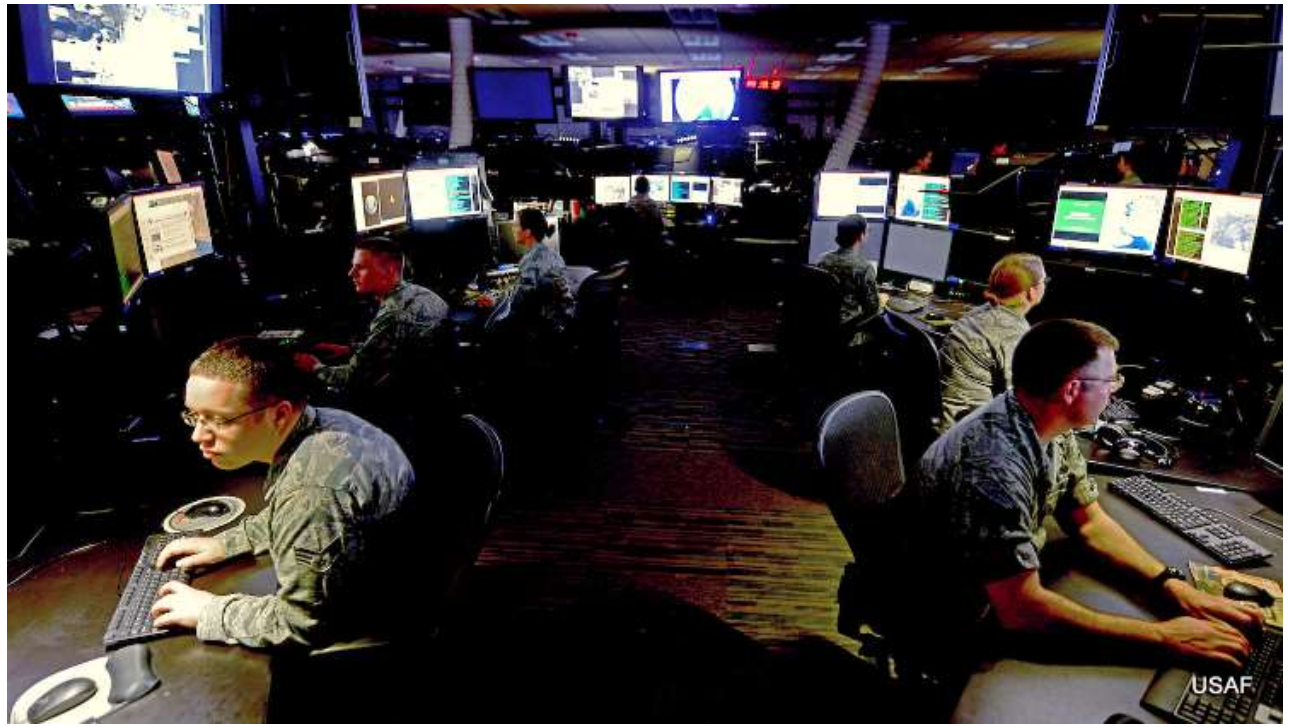
Mission Applications



Air Force Distributed Common Ground System
af.mil/News/Photos/igphoto/2000787787/

Who?

- Intelligence, surveillance, and reconnaissance analysts
  - e.g., Distributed Ground System (DGS) sites, Marine Corps Intelligence Activity (MCIA)

What?

- Intelligence tipping and cueing
- Aiding product generation
- Forensic analysis
- Human-machine teaming

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Project Artifacts

Current (FY17-18)

Video Summarization Pipeline

- Algorithms with code for object detection/tracking, segmentation, and summarization
- SPIE paper: “Applying Video Summarization to Aerial Surveillance”

Anomalous Tracks Detection

- Initial algorithms/code with SUMO simulator & LSTM autoencoder

Planned (FY19-20)

Anomalous Tracks Detection

- Create larger dataset with more anomalies
- Tune performance and compare with alternate approaches
- Test with DoD data and transition

Additional Pattern of Life Analysis

- Behavior analysis
- Scene building/templating
- Techniques to incorporate context

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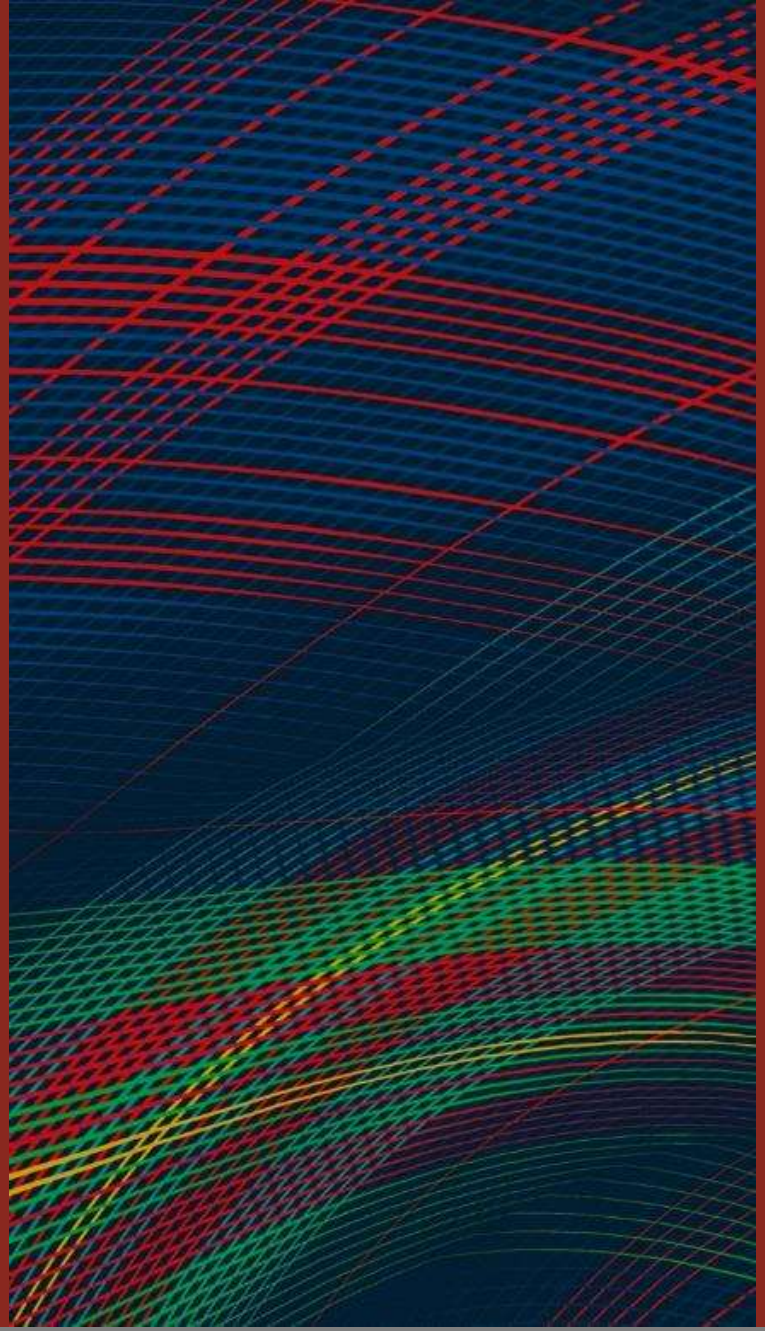
Software for Mission

Emotion Recognition from Voice



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Toward Machine-Emotional Intelligence

Current or Completed

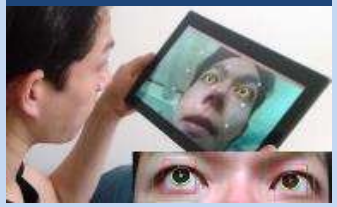
Heart Rate

Facial Microexpressions

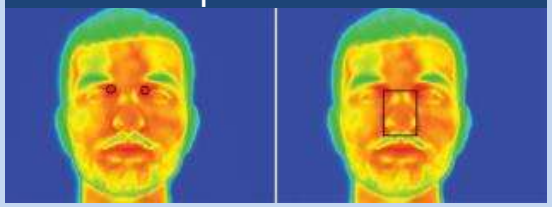
Voice

Proposed and Future

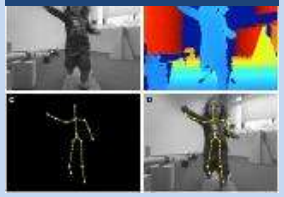
Gaze



Respiration Rate



Gait



Pupil Dilation

Perspiration

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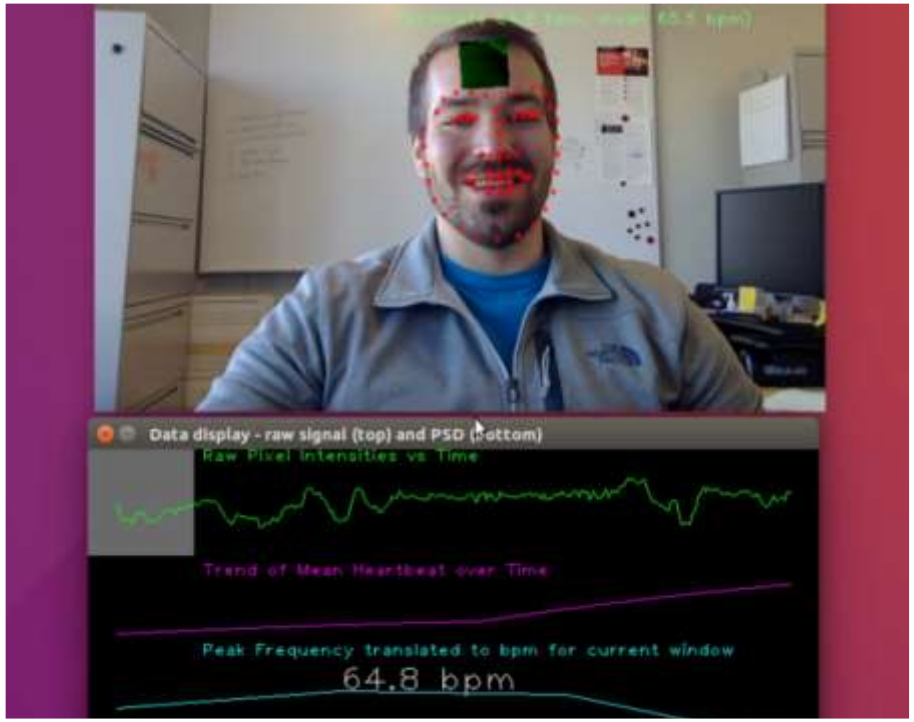
Passive Biometrics at the SEI

Real-Time Heartrate Extraction (2016)



Facial Micro-Expression Analysis (2017)

Used with permission of the Poker Channel:
youtube.com/user/sergeypoker/

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Voice Forensics at CMU Language Technologies Institute

U.S. Coast Guard photo by Eric D. Woodall

Profiling Hoax Callers

R. Singh, et al., 2016

This person is:

- White
- Brought up in the U.S.A.
- Approx. 175 cm tall
- Approx. 75 kg
- Approx. 40 years old
- Not in any trouble
- Not on a boat
- In a warehouse of some kind
- Using homemade equipment
- Sitting on a metal chair upon a concrete floor

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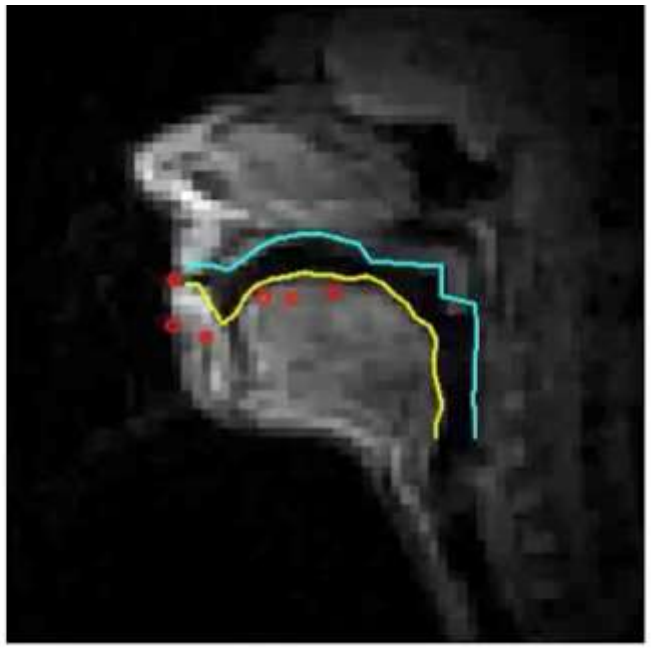
Emotion Recognition from Voice



- Voice is a complex process that presents bio-markers
- Bio-marker analysis enabled by **micro-articulometry**
- Made possible by 30 years of automatic speech recognition technology at CMU

“cat” ⟶ /k/æ/t/ ⟶ Micro-feature extraction

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Mission Applications

- Security checkpoints and encounters
- Interrogations
- Intelligence profiling
- Media analysis and exploitation
- Detection of stress, PTSD
- Human-machine teaming

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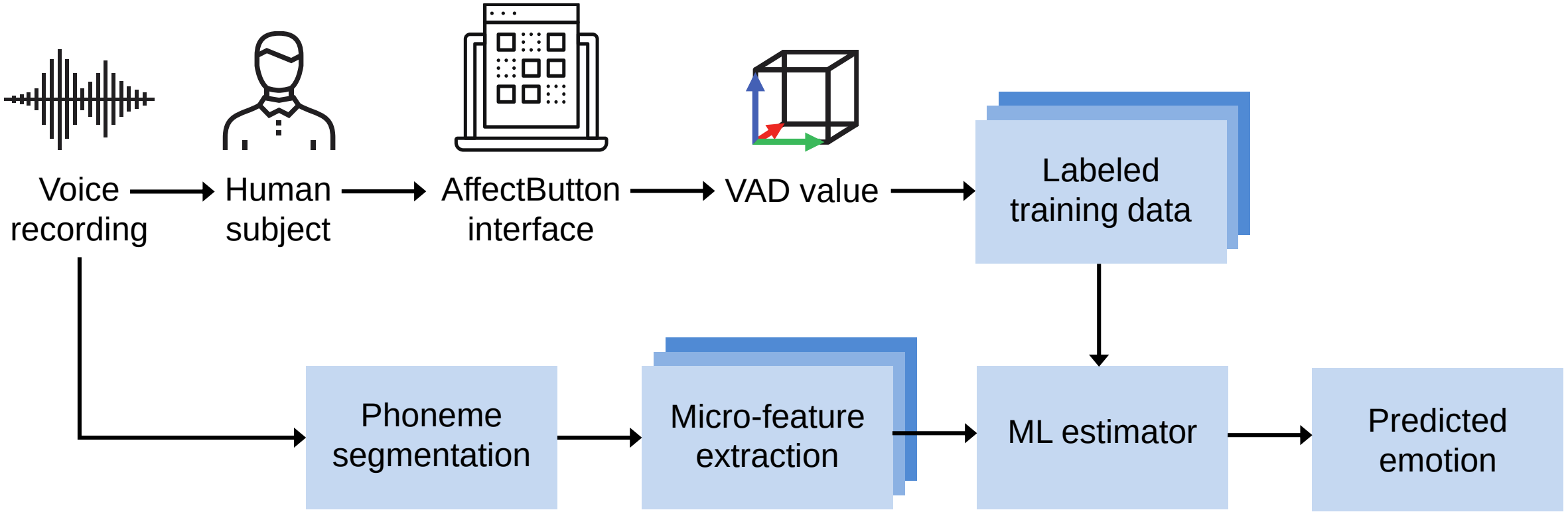
Emotion Recognition from Voice



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Progress and Expected Results

Completed

- Audio segmentation pipeline
- Crowd-sourcing web platform
- Baseline emotion classifiers using existing databases

Project Artifacts *(end of FY19)*

- The largest-ever speech emotion recognition database
- Emotion recognition prototype, powered by micro-articulometry and deep learning

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Semantic Ladder

- Decision
- Projection
- Comprehension
- Perception
- Sensation

Derived from: Endsley, Mica. *Toward a theory of situation awareness in dynamic systems*. Human Factors, 37(1), 32-64, 1995.

AI Stack

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