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Real-time Spatial Tracking as a Paradigm Shift for Next Generation Handheld Explosive Hazard Detection (HH-EHD) Technologies

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The Threat

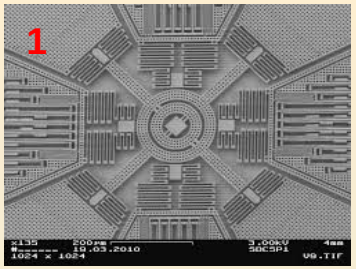
- **New and evolving target types**
  - Metallic and non-metallic
  - Manufactured and improvised
  - On route, off route emplacements
  - Urban and rural

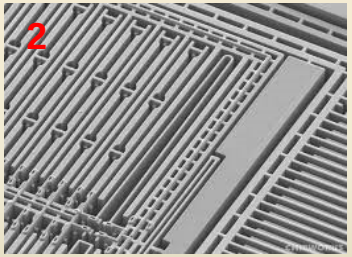
Handheld Position Sensing Technology Thrust

- **New potential for improved Handheld Explosive Hazard Detection (HH-EHD)**
- **Precise positioning**
  - Position (x,y,z) and Attitude (pitch,roll,yaw)
  - Position and Attitude together are “pose”
  - Require sufficient precision to resolve sensor responses
  - Enables new algorithms for handheld detection
    - Multi-sensor fusion
    - Threat imaging
- **Collect data from multiple sensors with precise position and attitude (pose information) to support algorithm development and evaluation.**

Enabling Technologies

- MEMS devices
- CMOS sensors
- Fast CPUs





1. http://www.geekmomprojects.com/geekmomprojects-wp/wp-content/uploads/2013/03/mems_gyroscope.jpg
2. http://qcn.stanford.edu/wp-content/uploads/2011/11/Kionix_MEMS_cross_branded.jpg
3. http://artofcircuits.com/wp-content/uploads/2014/04/Camera-Sensor-OV7660.jpg

Position Sensing

Candidate Sensor Types Assessed:

- MEMS Gyro/ Accelerometer
- Color camera
- Structured Light camera
- Laser rangefinder
- RADAR
- Magnetometer
- GPS
- Passive Radio Frequency Triangulation
- Optical mouse
- Acoustic ranging

MEMS Accelerometers with Camera based Optical Odometry Demonstrated

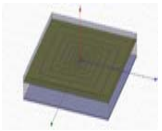
Data Collection

- **Robotic Collection Cart**
  - Position and Attitude (pose)
    - Cart pose from GPS/IMU
    - Sensor pose relative to cart during sweep from arm joint positions
  - Sensors
    - Ground Penetrating Radar
    - Multi-frequency Metal Detector
    - Pulse Induction Metal Detector

- **Test Site**
  - US Temperate Region Site
  - Target set included Anti-personnel (AP) and Anti-Tank (AT) mines, metallic and non-metallic Improvised Explosive Device (IED) types, pressure plates, and wires

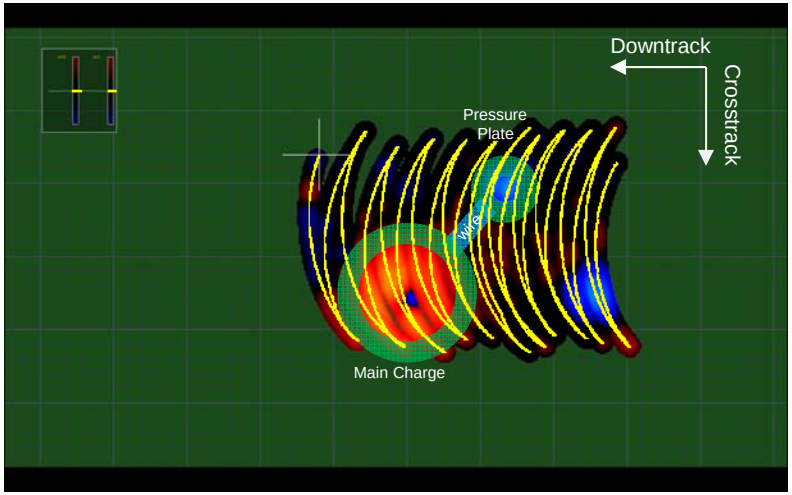
Real-time Spatial Location (1/3)

- **Provides real-time position and orientation (pose)**



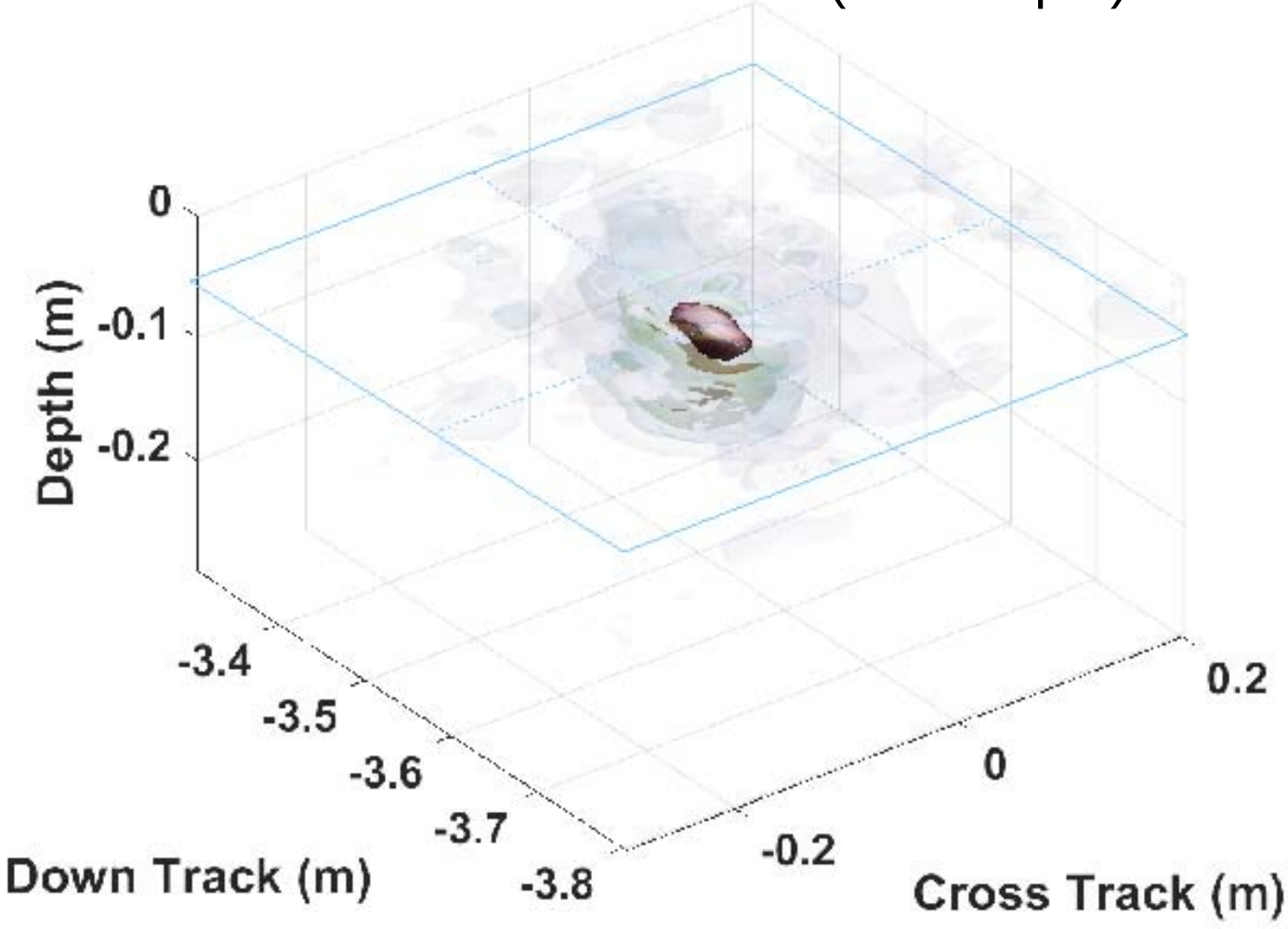
- **Enables sensor fusion**
  - Improve detection using information from complementary sensor types
  - Can align data from multiple sensors

- **Enables Advanced Algorithms**
  - Allows 2-D images
  - Use spatial context to detect multi-component threats
  - Allows 3-D imaging



3-D Handheld Radar Image Formation

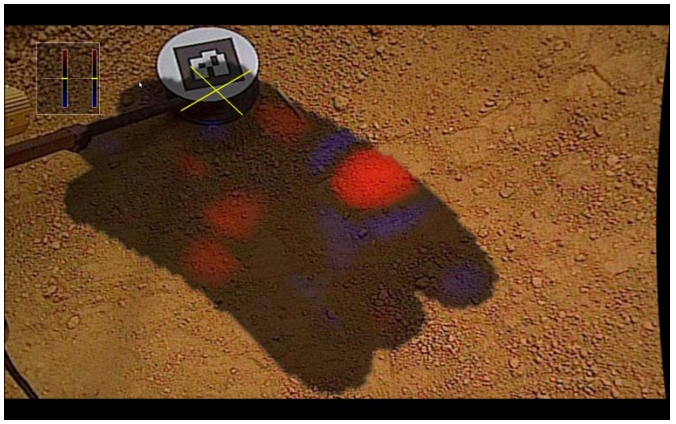
Metal Anti-Personnel Mine (5cm Depth)

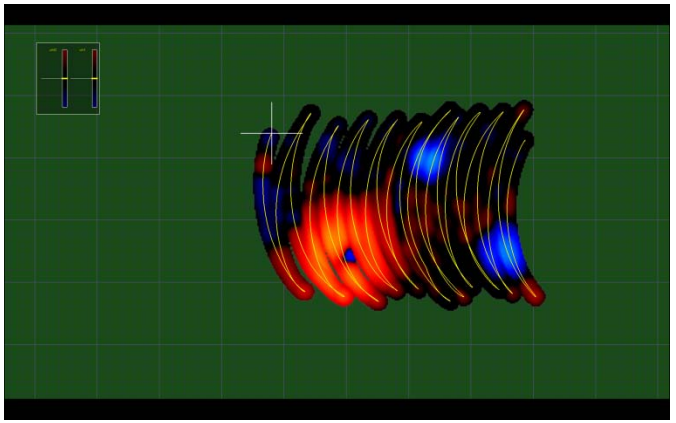


Real-time Spatial Location (2/3)

Improved Usability

- Direct “heads up” display of sensor response to soldier
- Simplified user controls using position as context for operation commands



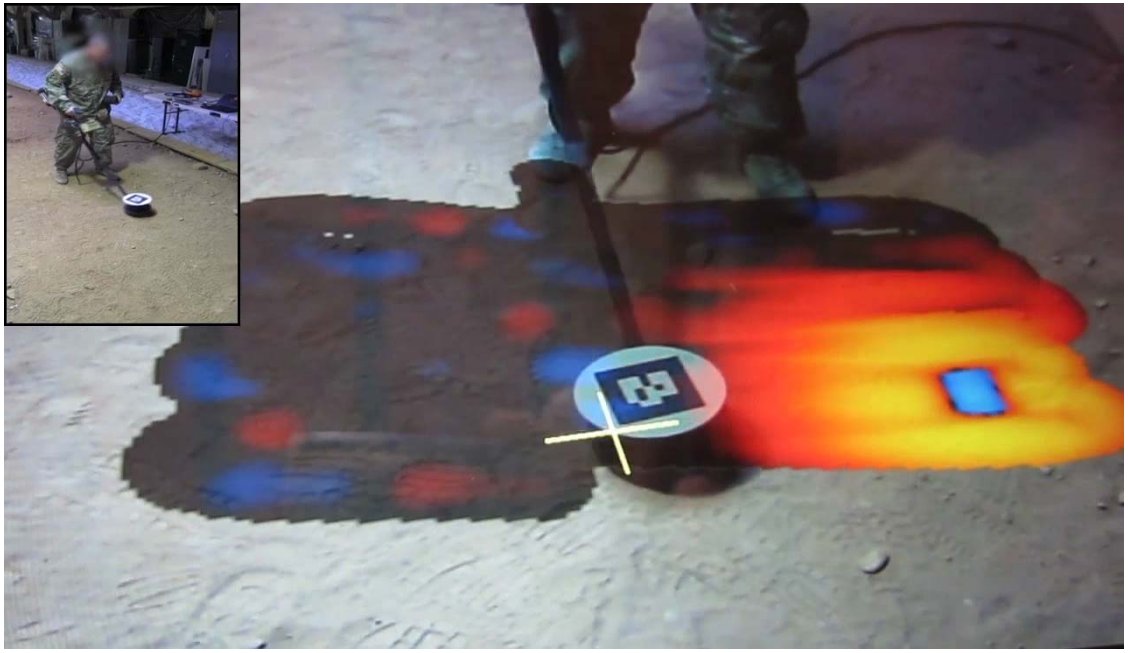


Real-time Spatial Location (3/3)

Training Improvements

- Display sweep image for immediate feedback
- Sensor can compensate for sweep variation between operators
  - Operators are not forced to learn a uniform sweep for correct functioning
  - Sensor can adapt to variations in *usage* by operators
- Reduces training burden
  - Less time to learn mechanics of swing
  - Intuitive operation using context and position
  - Allows for field training with or without an instructor

Conclusions



- **New HH-EHD detection algorithms**
  - Adaptive operation
  - Multi-sensor fusion
- **Intuitive operation and live visual feedback**
- **2-D and 3-D Imaging for Handheld Algorithms and Display**

Real-time Spatial Location Tracking Enables Next-Generation HH-EHD Technology