SAFETY AND EFFICIENCY THROUGH ADVANCED VIDEO PROCESSING

Transocean(1) & CoVar Applied Technologies(2)

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Transocean and CoVar Applied Technologies

Transocean

Offshore contract drilling:
technology focused,
safety oriented,
prototype piloting,
deployment partner

CoVar

Fast growing start-up
focused on:
machine intelligence,
computer vision
data analytics,
signal processing
advanced sensor H/W

Advancing safety
and efficiency in
drilling through
computer vision
technology

Leveraging technology base

Majors

Military

Commercial

CoVar Internal
The drilling rig is a dynamic, rapidly changing environment

Increased automation is key to improving safety and efficiency
  But automation comes with its own risks

Many pieces of information required for safe automation are difficult to obtain
  Difficult or expensive to instrument, require user cooperation
  E.g., transponders – require user action

Lots of information from visual interpretation of a scene
  How to automate?

Ensuring safety controls enable workers and drillers to confirm that the path of the iron roughneck is clear of personnel
Value of Video Data

- Can serve as primary early warning system
- Information rich data stream
- Extremely accurate
- Already available on many rigs
  - Potential leverage of existing video data sources given adequate camera placement
- Possible to combine with other technologies for orthogonal information
Video Processing Value

- Raw video is *unstructured*
  - Can’t point a video camera at a scene and automatically make decision (e.g., control a widget)
- Video processing extracts information from raw video to provide “structured” information by which decisions can be made
Leveraging Previous Experience

- Previous work in several DoD funded application areas
  - Real-time trip-wire detection in first generation digital night-vision goggles
  - Algorithms for road-cataloguing for potential IED detection

http://covartech.com/videos/dea2013Nov/#1
Example Application Area

- Rig floor automation
  - Potential interaction of multiple machines with multiple humans
  - Accurate knowledge of personnel locations become extremely important

- Where are people on the rig floor?
  - Can I move this equipment safely?
Goal
- Prevent machine-human collisions
  - Using pre-existing sensors
  - No personnel actions required

Technical challenges solved
- Infer locations of multiple people in a scene from a set of monocular cameras
High Level System Architecture

Central Computations

C1
C2
C3
CN

Front-End Visualization & Warnings/Control
Person Detection: Compare PVM to “OTS” Solutions

- **Fundamental challenge**
  - Find people in images

- **Algorithm evaluation criteria**
  - Probability of detection ($P_d$)
  - Probability of false alarm ($P_{fa}$)
  - PVM requires very high $P_d$, very low $P_{fa}$

- **Algorithm evaluation requires extensive truthing**

- **PVM provides improved performance compared to standard OTS approaches**
Tech. Improvements over OTS Technologies

- Person detection
  - Poor Off-the-shelf person detection performance
  - Developed classifier with manually labeled training data
  - Internally modified Histogram of Oriented Gradients (HOG) feature vectors
    - Shorter feature length
    - Faster to extract and classify
  - Modified training paradigm more closely approximates testing paradigm
Learning a Mapping from Image to World Space

- Pinhole camera model
  - reasonable approximation

- Projection of object onto image plane can be accomplished through:
  - Intrinsic camera transformation matrix
  - Extrinsic camera position (x,y,z) and orientation matrix

- Extrinsic requires
  - Careful camera placement information
  - Or learning from fiducials (6 DOF, so > 6 fiducial locations)

- Leverage least-squares, or RANSAC, or other approaches

- In application:
  - Learn one intrinsic matrix in lab (once)
  - Learn extrinsic parameters on rig using fiducials; should be automatic
Person Location via Triangulation

- Person location via triangulation requires
  - Person detections in images (image space)
  - Camera transformation information (image → world transformation)
  - Multiple cameras
- Back project detections into world space, accurately triangulate person location

Dashed lines indicate camera view intersection with floor
“Ghosts” in Bearings-Only Triangulation

- Two real objects at locations, X
- Both objects detected in all cameras
- Real objects indistinguishable from ghost/alias objects at locations, O
  - Uncertainty in bounding boxes due to person motion exacerbates problem
Methods to Reduce Ghosting Effects

- **Simple approach**
  - Define close person detections as “group”
  - Expand safety region around group
- **Alternatively, leverage constraints on # of people**
- **Require person persistence**
  - Requires tracking
    - Various approaches to tracking
      - E.g., Kalman, EKF, Particle
      - Currently use proximity based tracking
- **Optimize placement of cameras**
Real-Time Processing Framework

- **Technology challenges:**
  - Algorithmic – person detection, tracking, etc.
  - Implementation – real-time multi-thread coding, debugging
- Implementation often goes under studied by algorithm developers
  - This is a big mistake… implementation and algorithms must be coupled to make headway
- Transition from MATLAB to real-time C++ is nontrivial task
- Leverage commercial tools
  - QT, OpenCV, GoogleProtocolBuffers, C++, UDP, etc.
- Develop custom tools as necessary
Current Hardware/Software

- 5 mini form-factor Intel computers
- Linux Mint v15 operating system
- Communicate via Cat5 cables and ethernet switch
  - Internet access not required
- Single monitor/keyboard/mouse
- Connected to 4 (or 5) Logitech cameras
  - Connect via USB 2.0, with USB 2.0 Extension cables
Prototype Real-Time Mapping Operation


- Video shows person entering room, picking up object, exiting.
- Persons fully tracked during this action.
Underlying Processing

Raw Detection Confidences

Tracking Results

Real-Time Demo Video

Example real-time demonstration of PVM –
Persons are only tracked when inside marked region of floor.

Current System Constraints

- Too many people in too close proximity can result in
  - Missed persons due to persistent person occlusion
  - False detects due to person aliasing
- Current operating constraints include 2-3 person max (depending on room size)
  - Goal: unlimited (< 20) persons tracked in one scene
  - Requires additional cameras, potential over-head cameras
- Each camera operates in its own thread
  - No computational limits on number of cameras that can be incorporated, or spatial region
Other Technology Application Areas

- **Other:**
  - Automated vehicle driving (automated video game playing)
  - Pipe localization in 3-D
  - Improvised explosive device detection
  - Doorway monitoring
  - Slip joint position monitoring
  - Particle sizes and solids volume estimate for shale shakers
  - Tripwire detection


Development and Deployment

Incremental Development and Deployment MITIGATES RISK and PROVES TECHNOLOGY VALUE
Summary

- CoVar/Transocean developing real-time Personnel Video Monitoring (PVM) technology for next generation of rig safety and efficiency

- Current results show
  - Extremely robust person detection in multiple cameras
  - Very accurate person localization
  - Real-time capabilities

- 2014 milestones
  - Enhance performance to meet real-world constraints
  - ID and deploy component technologies to minimize development risk
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