Automated Workflow and Activity Recognition at the Pediatric Intensive Care Unit

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Intensive Care Units are hectic.

Hundreds of micro-tasks
- Drug administration
- Emptying chest tubes
- Diagnostics
- Minor operations

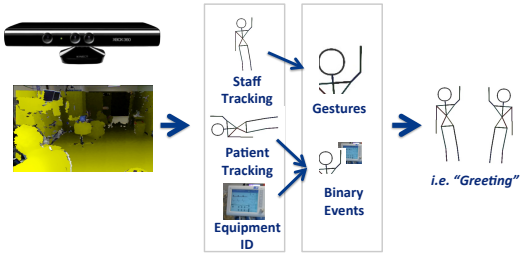
Lack of written direction
- Which nurse does what?
- Hierarchy of staff
- Rules handed down

Goals:

Automatic monitoring of personnel activities
- Increase safety by ensuring task completion
- Optimize workflow to minimize cognitive load
- Efficiently allocate staff and resources
- Distribute workload based on personnel skill

Approach

- Place 3D cameras in the Pediatric ICU
- Extract meaningful features from depth images
- Feed features into action classifier



Derived Features

A 22-Dimensional vector describes each action

Summary Statistics

Path Length
Velocity
Center of Mass
Duration

Virtual Touch Sensors

Orientation Histogram

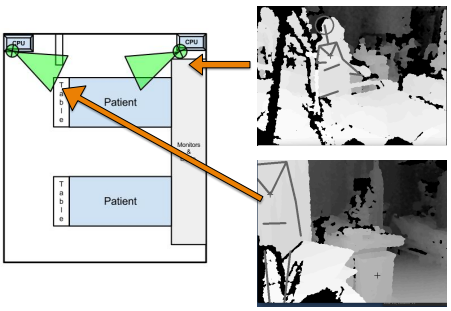
Estimate based on PCA

Calculate histogram within action sequence

Interaction Coefficient

Calculate projection of orientations

Setup

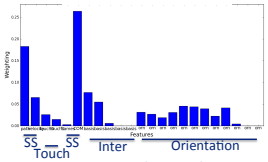


Recognition

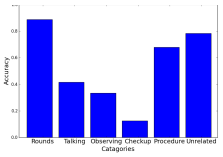
Classify 7 actions:
* Observing
* Ventilator use
* In-bed procedures
* Talking
* Urine tube removal
* *Computer documentation
* Checking vitals

Support Vector Machine: Produces linear separator using high-dimensional representation (Set #1 Avg: 48%)

Decision Forest: Generates many simple decision trees based on randomly picked features (Set #1 Avg: 58%)



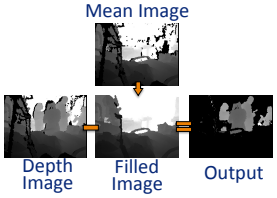
Importance of each feature In the Decision Forest



Per-class accuracy for Decision Forest on dataset #1

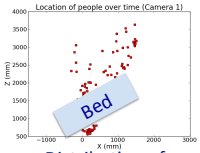
Segmentation

Images:
- Background subtraction using averaged set of images
- Fill in errors with nearest neighbors
- Remove noise with morphological filters



Example Segmentation

Actions:
- Center of mass is tracked over time
- Combine segments that are similar spatio-temporally as sequence



Distribution of action locations

Progress

- IRB approval in PICU
- 13 hours of recorded data
- Framework for feature extraction and action recognition
- Preliminary recognition results
- Prelminary work on gestures and skeletal tracking

Future work

- Fuse cameras into single frame
- Explore other classification methods
- Person differentiation
- Implement skeletal tracker and incorporate hand movement
- Investigate patient movement

PICU Statistics
- 24 minutes of contact per hour
- Most time spent **checking vitals**

Acknowledgment: Equipment supplied by the Applied Physics Lab