Fall Detection on Embedded Platform Using Kinect and Wireless Accelerometer

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In this paper we demonstrate how to accomplish reliable fall detection on a low-cost embedded platform. The detection is achieved by a fuzzy inference system using Kinect and a wearable motion-sensing device. The foreground objects are detected using depth images obtained by Kinect, which is able to extract such images in a room that is dark to our eyes. The system has been implemented on the PandaBoard ES and runs in real-time. It permits unobtrusive fall detection as well as preserves privacy of the user.

Agenda

- Fall detection problem
- Our approach
- The Fall Detection System
- Experiments
- Summary

Fall detection

- Fall Detection isolates falls from activities of daily living (ADLs).
- The goal of fall detection technology is to detect the fall occurance as soon as possible and generate an alert.

Fall detection: facts

- Falls are major causes of mortality and morbidity in the elderly.
- From 20 to 30 percent of those who have fallen have medium to severe injuries.
- Half of those, who have fallen can not get up without help.

Fall detection: primary challenges

- Reach high performance of fall detection
- Reduce number of false alarms
- Generate alarm as quickly as possible
- Preserve user privacy

Fall detection: approaches

Since falls are usually characterized by larger acceleration compared with ADL, existing solutions mainly use accelerometers and gyroscopes for detection.

- Several ADLs have similar kinematic motion patterns with real falls (false alarms).
- Inadequate to be worn during the sleep.

Fall detection: approaches

Attempts have been made to detect falls using vision system, consisting of: single camera, multiple cameras or omnidirectional-cameras.

- CCD-camera based solutions require time for installation, camera calibration and they are not generally cheap.
- Can not work in nightlight or low light conditions.

Our approach

- Use two sources of data:
  - wearable motion sensor
  - Microsoft Kinect (utilize depth images only).
- Use Takagi-Sugeno type fuzzy inference system as a classificator of fall or non-fall events.
- Run the system in real-time on single-board computer PandaBoard ES.

Vision device – Microsoft Kinect

Combines depth and RGB camera

IR projector and camera makes stereo pair

Low cost (arround 125$)

Open-source community drivers

Vision device – Microsoft Kinect

- Measurement of depth as a triangulation process:
  - the laser source emits beams capured by camera
  - capured patern is correlated against reference pattern
  - dispaity values are obtained
- Distance from device could be calculated: $Z_k = \dfrac{Z_o}{1 + \dfrac{Z_o}{fb} d}$

Mobile platform – PandaBoard ES

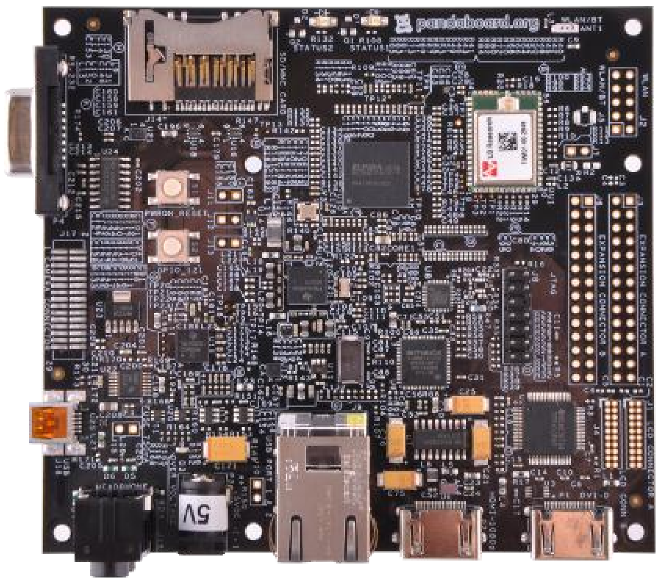
ARM architecture

Dual-core ARM Cortex-A9 1.2 GHz

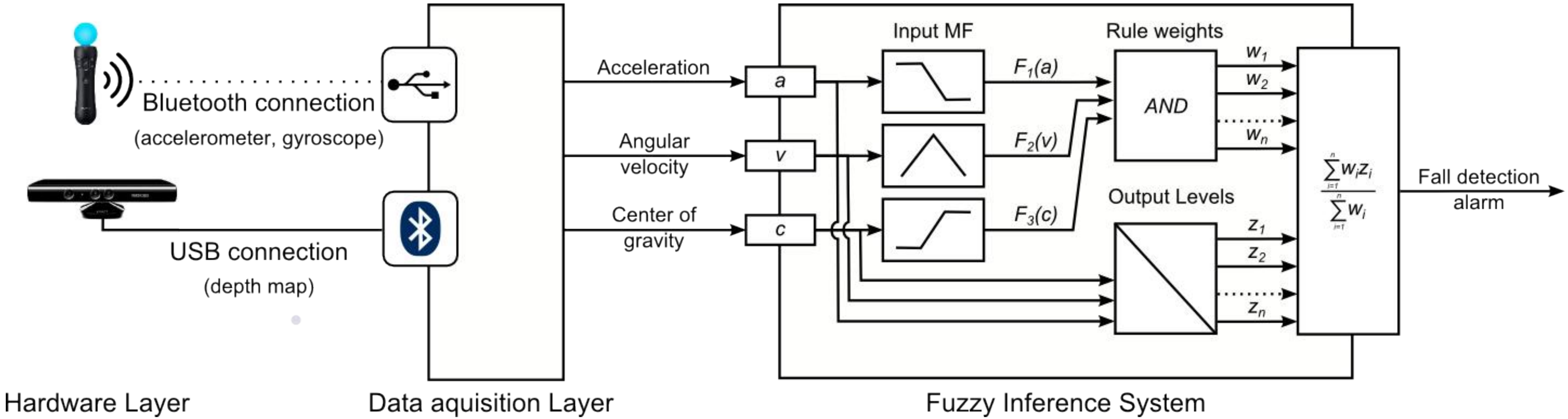
1 GB RAM

Linux OS

Dimensions: 114.3 x 101.6 mm

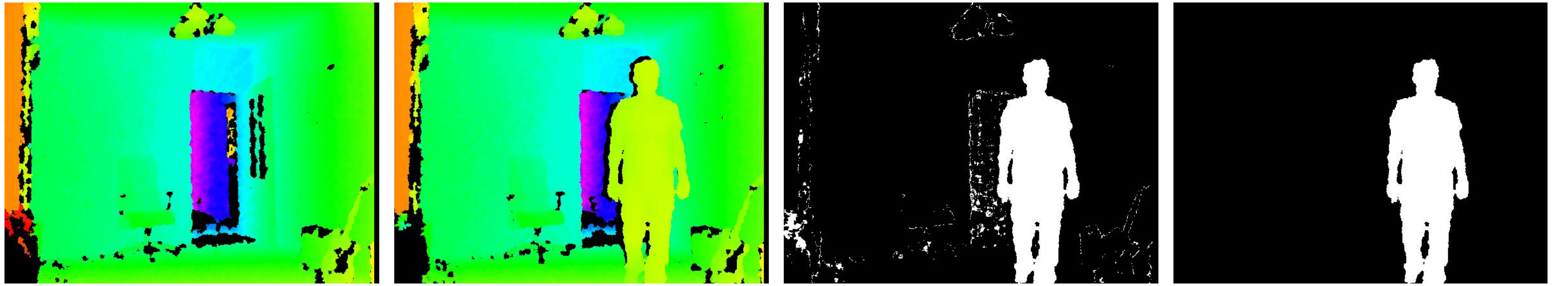


Fall Detection System: architecture



Fall Detection System: algorithm

Extraction of the Object of Interest:



Center of gravity calculation:

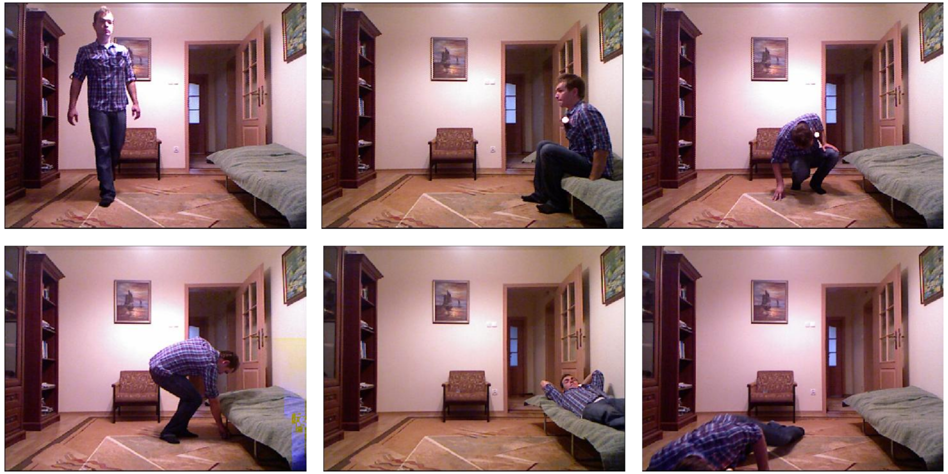
$$X_k = -\frac{Z_k}{f}(x_k - x_o + \delta x) \quad Y_k = -\frac{Z_k}{f}(y_k - y_o + \delta y) \quad c(x,y) = (\frac{\sum_{i=1}^{n} X}{n}, \frac{\sum_{i=1}^{n} Y}{n})$$

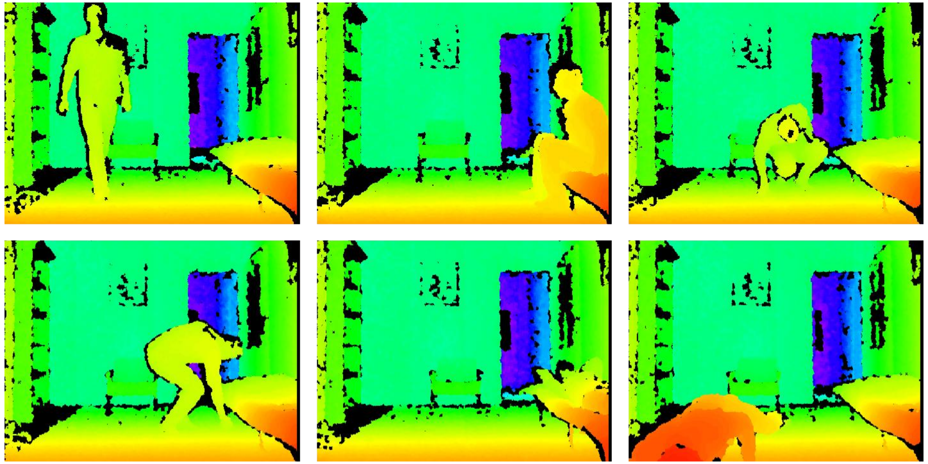
Experiments

- Five volunteers with age over 26 years attended in evaluation of our developed algorithm and the system.
- The accelerometer was worn near the pelvis.
- Each individual performed three types of falls, namely forward, backward and lateral at least three times.
- Each individual performed ADLs: walking, sitting, leaning down, crouching down, picking up objects, lying on a bed.

Experiments

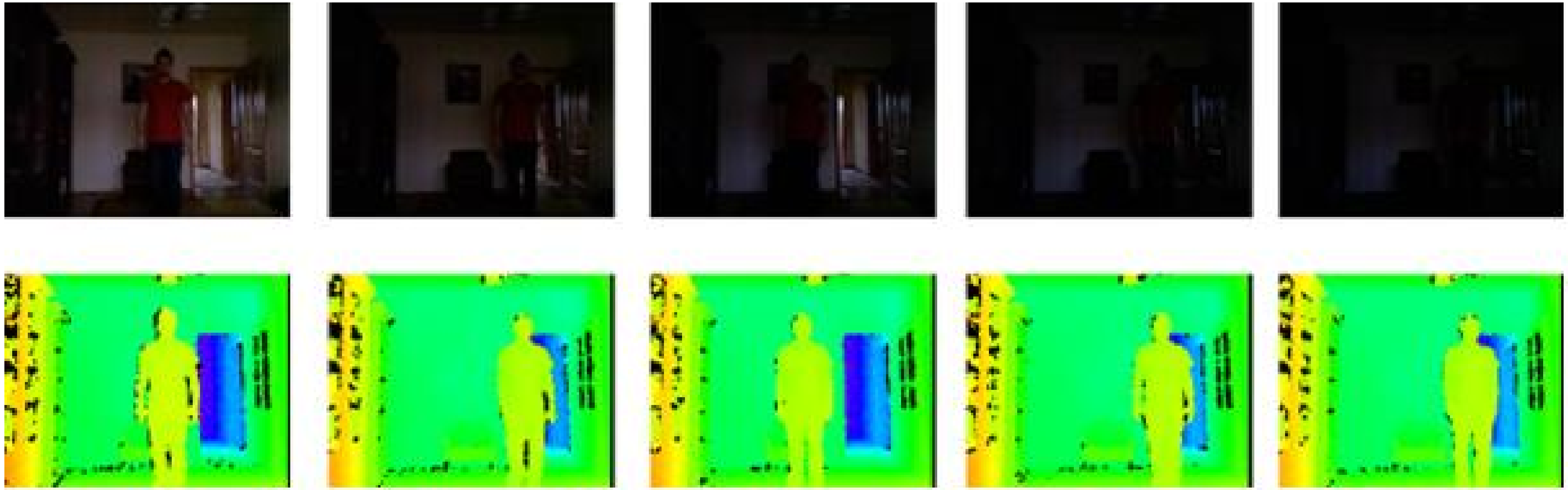
Falls and non-fall events (ADLs) during system evaluation:





Experiments

Depth and corresponding RGB images during various light conditions:



Results

All intentional falls performed in home towards the carpet were detected correctly.

The system correctly detected seventeen falls of the eighteen falls in the gym towards the mattress.

fall	sitting down	crouching down	walking	lying in a bed	picking up objects
27/28	23/25	23/25	25/25	12/12	25/25

Summary

- In this paper we demonstrated how to achieve reliable fall detection on an embed-ded platform.
- The detection was done by fuzzy inference system using Kinect, accelerometer and gyroscope.
- The system runs on low-cost PandaBoard ES.

Summary: strengths and weaknesses

- \+ Depth camera preserves privacy better than CCD camera.
- \+ IR camera allows to work in weak light conditions.
- \+ The system could operate with only one source of data.
- \+ No additional wiring of the house (or room) is needed.
- – Area, which can be monitored by Kinect is limited.
- – Kinect is unsuitable for working outside on daylight.