Basic Human Motion Tracking Using a Pair of Gyro + Accelerometer MEMS Devices

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http://www.embs.org/

Agenda

- Purpose
- Experimental Setup
- Pose Recognition
- Feature Extraction
- Experimental Results
- Pose Difficulties/Improvements
- Conclusion

Purpose

To initiate further research in human motion sensing applications using a combination of accelerometers and gyroscopes on a dual module design mobile phone platform.

Figure 1a: DDR logo
http://en.wikipedia.org/wiki/Dance_Dance_Revolution

Figure 1b: Fujitsu F-04B
http://www.slashgear.com/fujitsu-f-04b-modular-cellphone-with-pico-projector-gets-played-with-1263375/

Experimental Setup

Figure 2a: IME-3000

http://www.invensense.com/mems/gyro/imu3000.html

Figure 2b: IDG-500

https://www.sparkfun.com/products/9070

Figure 2c: ISZ-500

http://www.invensense.com/mems/gyro/isz500.html

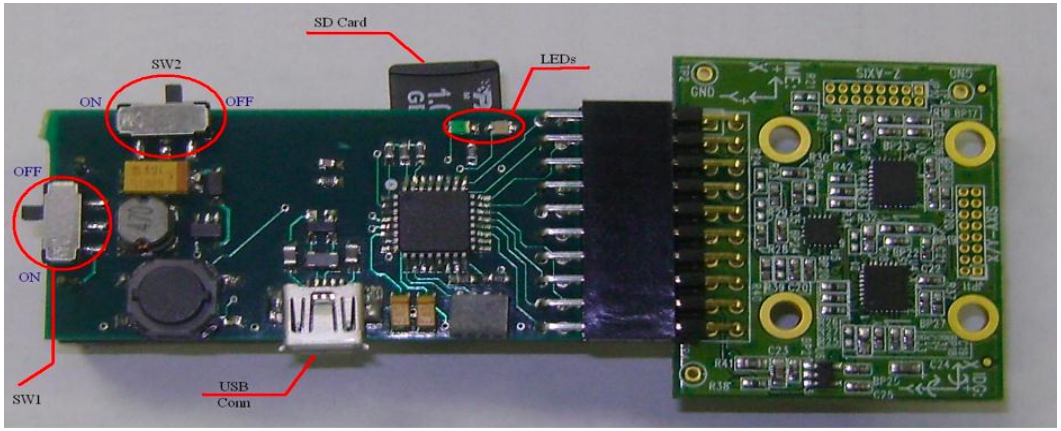


Figure 2d: IHU-500 (integrated sensor board mobile platform)

Close - up

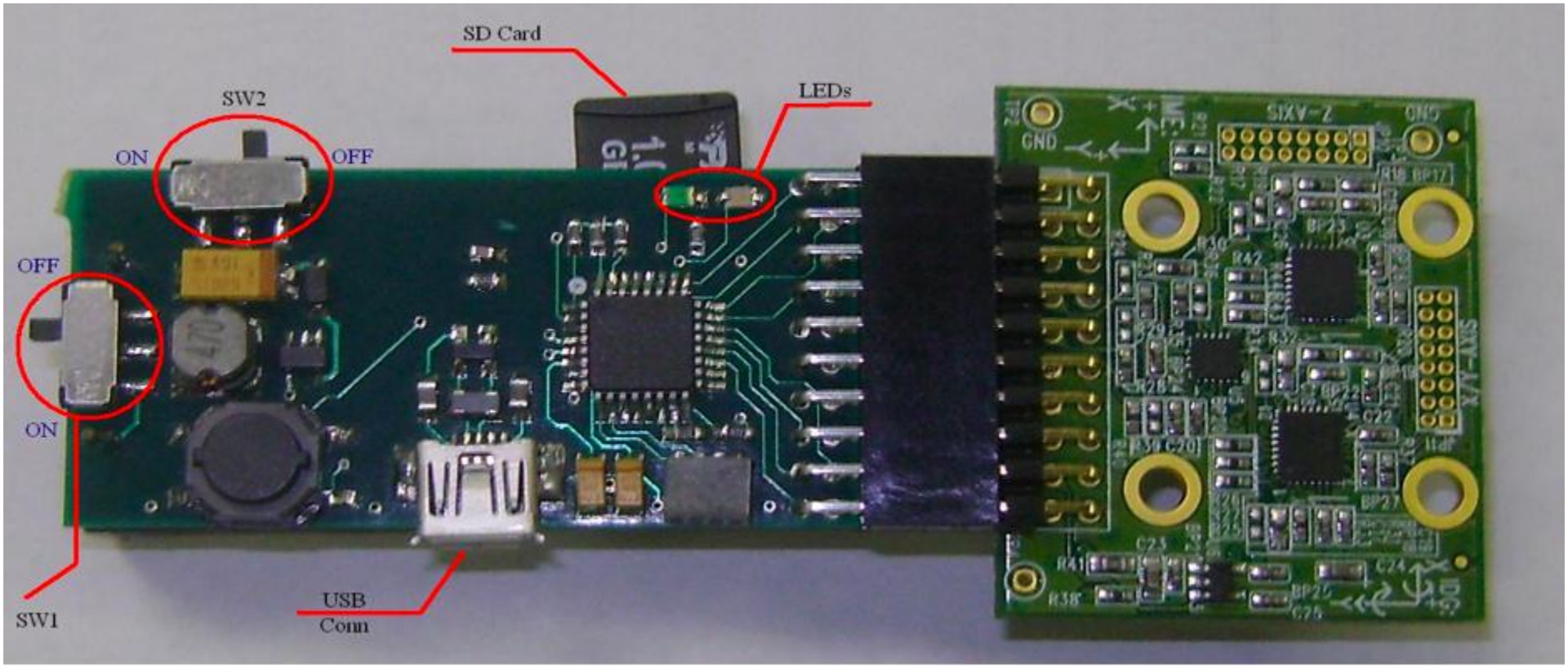


Figure 3: Integrated sensor board close-up

Pose Recognition

- To develop a “raw” dataset, test subjects performed each pose 50 times.
- Parameters:
  - *x,y,z* accelerations
  - Pitch (counterclockwise rotation y axis)[1]
  - Roll (counterclockwise rotation x axis)[1]
  - Yaw (counterclockwise rotation z axis)[1]
- Thus, a “pose dictionary” was created for comparison of incoming data to raw data.

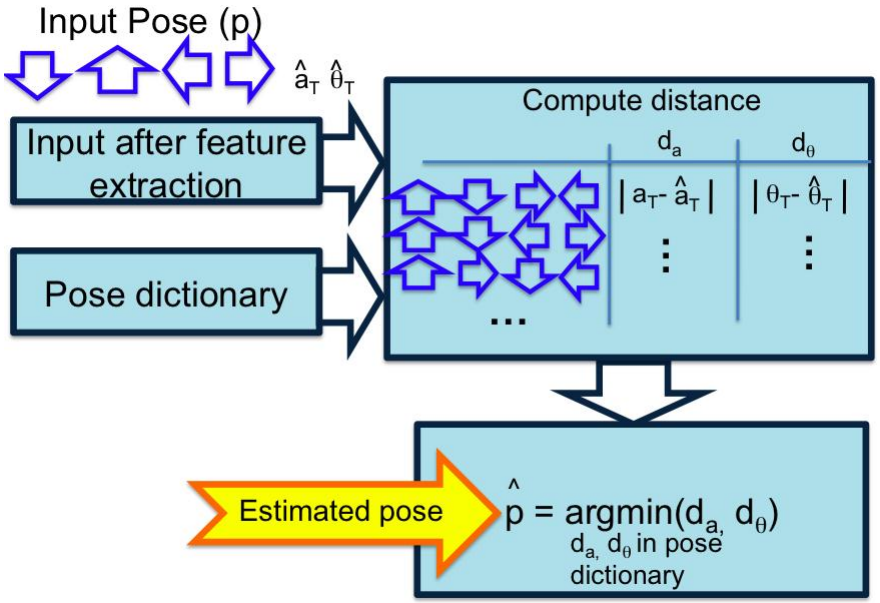


Figure 4: High-level flow chart of classification algorithm

Pose Recognition

Experiment 1

- 1 board on ankle, 1 board around waist
- 24 different poses

Experiment 2

- 1 board on ankle, 1 board on palm
- 5 different poses

Experiment 3

- 1 board on ankle, 1 board on torso
- 5 different poses

- The ‘points of motion’ were detected for every dance pose in DDR.
- These points were then used to create a ‘pose dictionary’ or ‘classification algorithm’ to distinguish dance moves.

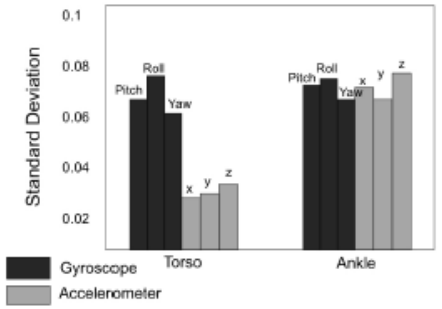
Feature Extraction

1. **Segmentation**: Used to determine the beginning and end of each pose. (Typically begins with a jerk and fast acceleration.)
2. **Filter:** Two low pass filters to eliminate noise/error in the data
3. **Classifier**: The pose data taken from the accelerometer and gyroscope is compared with the pose classifier obtained during the training phase.

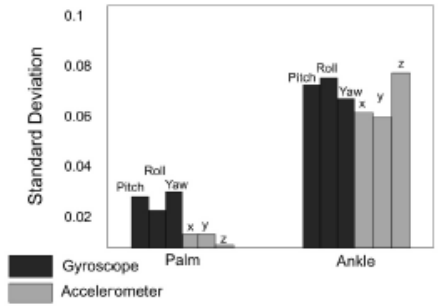
- The distance between a sample input and the mean of the trained samples is computed.
- If this distance parameter falls within a certain threshold, the pose is declared to be detected.

Experimental Results

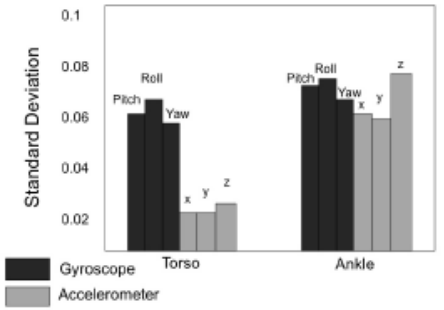
- Larger the standard deviation, higher probability for success
- Smaller the standard deviation, lower probability for success
- Standard deviation based on:
  - Person recording the pose
  - Complexity of the pose
  - Amount of practice of test subject
  - Recording time



(a) Experiment 1.



(b) Experiment 2.



(c) Experiment 3.

Figure 5: Standard deviation results

Pose Difficulties/Improvements

- Different body types and physical limitations impacted accuracy.
- A larger data set using test subjects with a diverse body type could provide more accurate results.
- The same test subject could not exactly replicate the same pose for the training data set, due to human error.

Figure 6: DDR Console

http://media.gamerevolution.com/images/misc/clinton-playing-ddr.jpg

Conclusion

A combination of accelerometers and gyroscopes can be used to detect and determine human motion (ie. in DDR dance poses) with a reasonably high probability.

The results proved that there is potential in further research of mobile gaming using dual mode design mobile phones.

This same technology can be used to help track and monitor movements of the elderly, therefore creating greater independence for them to stay in their own home.

References

[1] S.M. Lavalle, “Planning Algorithms.” Available: http://planning.cs.uiuc.edu/node102.html