

Detecting Exceptional Actions Using Wearable Sensors' Data for Developing Life-Log Database of Visually Impaired People

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Abstract

This paper proposes our approach to develop a system supporting visually impaired people with life-log. Visually impaired people face daily problems because of lack of information about road conditions. To find the uncomfortable and dangerous points, detecting their exceptional actions, such as tumbling down and getting lost, is effective. In the experiments, we used two units of iPod touch as wearable devices, and measured visually impaired people's walking as acceleration patterns. As a result, several useful actions appear in acceleration patterns.

Introduction

For today's developed cloud computing and ubiquitous era, life-log is an indispensable element to improve various kinds of software more intelligently. People may think our life has nothing to do with life-log, but actually, we use this epic system in our daily life even unconsciously. Life-log can make our life more convenient, for example the recommendation system of Amazon, or "Food-Log" [1] extracting lack of nutrition by snapping and processing image of daily food. We believe that life-log can be used to support walking disability people, such as wheelchair users and visually impaired people walking with a white cane, and we have been developing life-log applications for those people [2][3].

In this paper, we analyze visually impaired people's walking with life-logs. Those people who have visual impairments faces many uncomfortable situations when walking, for example, differences on ground and unconstructing of tactile indicator may make them uncomfortable, even though these factors are nothing for non-impaired people. However it is practical and obvious big problem for visually impaired mobility, clarifying the

uncomfortable points for impaired people needs a lot of manpower and high assessment ability, so there are no available information about accessibility of roads. This situation is an obstacle for them to go out casually.

To improve road accessibility, traditional approaches have been focusing on environmental modification techniques, such as repairing of roads' surface. Actually it is indispensable to eliminate the cause of the problem, but it takes a lot of cost and time. Moreover, modifying all roads not only help people, but also sometimes confuse them, for example, tactile indicator is necessary for visually impaired people, but it make wheelchair users uncomfortable. Thus, we need another approach.

To deal with the problems, our goal is making the map to visualize accessibility of roads. With using the map, users can know where barrier is in advance of walking. Social sharing platform of barrier-free information is good idea [3], however; we believe that life-log is effective for evaluating accessibility because life-log is a living witness to discomfort or risk of the route where he/she walked. In life-log fields, some researches attached sensors to a white cane and recorded their daily activity [5][6][7]. This way is effective to detect and avoid obstacles, but it is not suite to our purpose because white cane is only one part of their walking, so white cane's sensor cannot record their entire walking such as the movement of body. Thus we attach sensors to human body in the work.

This paper analyzes visually impaired walking with life-log as first steps to make the map to visualize road accessibility. The rest of this paper is organized as follows: Section 2 devotes to summarizing our system. Section 3 describes our original walking life-log and experiments that we conducted. We then present results of analysis from two viewpoints, activity recognition and human identification. Finally, Section 5 concludes the paper.

System Overview

As we mentioned at previous chapter, visualizing accessibility of road is one of the best solution to help visually impaired people's walking under outdoor situations, and to enhance their motivation to go out. Fig. 1 shows a whole image of our system. Our system has three main models, sensing model, estimation models, and mapping model. A basic idea of our approach is mining uncomfortable points from walking life-log. The middle model, the estimating model takes on a role to classify life-log into activities. By classifying the activities, we can know where getting lost, tumbling down, or impinging happened, and the information is effective to predict the points where people tend to take a lot of troubles. Moreover, walking life-log is highly personal information, so we could develop a personalized discomfort map. For instance, walking life-log potentially has personal property information such as walking ability, and habits of walking. Also, simple log of the places where he/she took a trouble is personal information because the place directly shows his/her preference and similar places may cause similar accidents. By estimating and logging such personal information, we can classify users into some group and then personalize the map suite to their abilities or preferences.

According to the survey [8], there are three major ways to record and recognize human activity, video sensor based activity recognition (VSAR), wearable sensor based (WSAR), and object usage based (OUAR). VSAR approach was reported to achieve high recognition rate at least in laboratory environments, but we adopt WSAR approach to our system, because wearable sensor is easy to bring, so it is suited to record human activities in daily life. In the sensing section, we suppose to use two kinds of

sensor at the present time, accelerometers and a position sensor such as GPS or quasi-zZenith satellite system [9]. Inertial sensors such as accelerometers, gyroscopes and magnetometers are popular in human action recognition fields [10][11][12], so we apply accelerometers to record daily activities. Position information is utilized for locating the places where the recognized activity was taken. At last, in the mapping section, estimated accessibility information is mapped to web map. Every user can access the map, and get accessibility information estimated from users' life-log in advance of going out. Then, visually impaired people reduce risks of accidents or some uncomfortable situations by selecting better routes.

Walking Life-Log

In this paper, we use original life-log recorded on experiments. Seven visually impaired people participated in the walking experiments and then wearable sensors recorded their life-logs as time-series of acceleration values. Participants' information is shown in table 1. All of seven participants are total blind and emerged his/her impairments at least 6.5 years ago. As wearable devices, we adopt iPod touch because it is inexpensive and embedded with powerful sensors including 3-D accelerometers and GPS. Also, the high diffusion and versatility is one of the big reasons. Special-purpose device such as eWatch [13] may be one option, but many people don't like to bring special devices. We are aiming at a more casual system everyone can use with his/her own devices.

In the experiments, participants required to walk in some situations such as with a helper, without helper, or with stressful task. In this paper, we mainly investigate life-log of one of the experiment that is most similar to situations

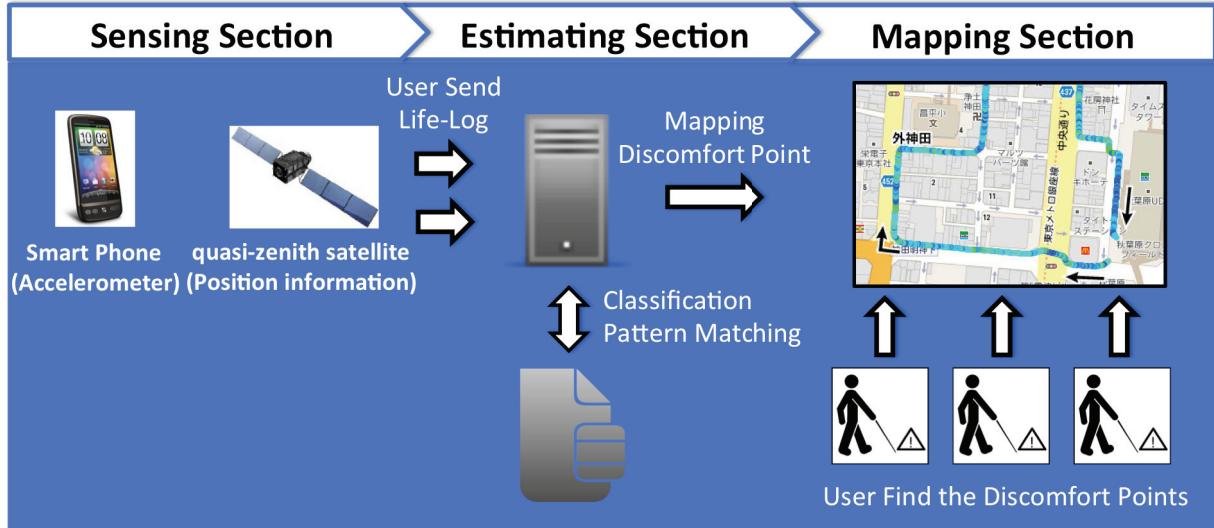


Fig. 1 Whole Image of the System

Table 1 Participants' Information

	Gender	Age	Detail of Disability	Experiment on Walking Training	How long his/her live with disability	Walking with Helper or not	Frequency of Walking
P1	F	64	Total Blindness	1 year	19.0year	YES	2, 3days per week
P2	M	68	Total Blindness	0.5year	26.0year	YES	Nothing
P3	M	62	Total Blindness	0.5year	6.5year	YES	2, 3days per week
P4	F	18	Total Blindness (Light Sence)	10year	16.5year	NO	Almost All Day
P5	F	20	Total Blindness (Manual Valve)	3year	7year	NO	2, 3days per week
P6	M	20	Total Blindness	3year	10year	NO	Almost All Day
P7	M	33	Total Blindness	14year	33year	NO	Almost All Day

of daily walking. Fig. 2 is a picture which taken at the experiment. This picture shows environments of experiment well. In the experiment, each participant walks independently from a start to a goal through a designated route. The route was designed as visually impaired people can follow tactile indicators, which mean all paths of the route have tactile indicators. The route was instructed by an instructor who walks besides the participant as the direction at each warning tactile indicators. For instance, when a instruction is 'left left and right', turning left at first warning indicator, turning left at second indicator, and turning right at third indicator is a correct route. So users need to detect warning tactile indicators and remember directions similarly with their daily walking.

As shown in Fig. 2, one iPod touch is attached to waist (waist sensor). We attach this position expecting to detect main activities. The other one is attached to upper arm (arm sensor) whose side of hand has white cane. The reason why we select this position is that white cane is an important factor for their walking. They search around and try to grasp surroundings information, e.g., if obstacle is exist or not, and if there is tactile indicator or not.

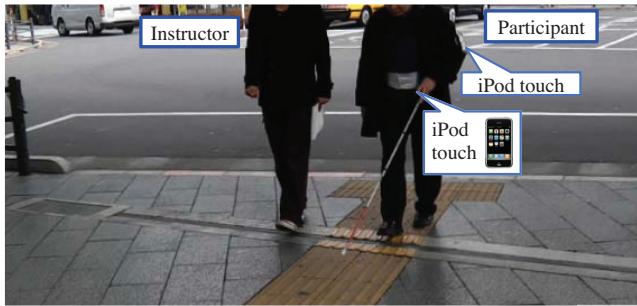


Fig 2. Walking Experiments with two Units of iPod touch

Acceleration Patterns

1 Human Activity Recognition

Investigating features of actions in acceleration signals is indispensable element to develop life-log database and recognize human activities. To focus on features of activities itself, this section deals with single participant's acceleration signals. The participant is Subject P7 in the table 1. In the experiment, he walked correct route smoothly during most time, however; sometime got lost and took some unusual action. Fig. 3 shows acceleration signal of two sensors attached to waist and arm when he was walking, resting, turning left, turning right, hitting his white cane on ground difference, stepping out and back an leg, shaking white cane, and turning back. Characteristics of each acceleration signals are as follow.

(A). Walking

Fig. 3-a illustrates walking acceleration signals and two regular patterns are observed. First, in the horizontal direction, a signal of one step had two peaks (in this paper, one step mean between one leg's heel contact ground to the other leg's heel contact on ground). First peak is occurred when one leg contact on ground and second peak is occurred when the other leg's toe leave ground, the accelerations of the travelling direction are positive between the two peaks.

(B). Resting

The signal pattern of stopping is very simple as we expected. When he stops, there is almost zero vibration in any direction as shown in Fig. 3-b. Existing vibrations seems to be noises of iPod touch sensors.

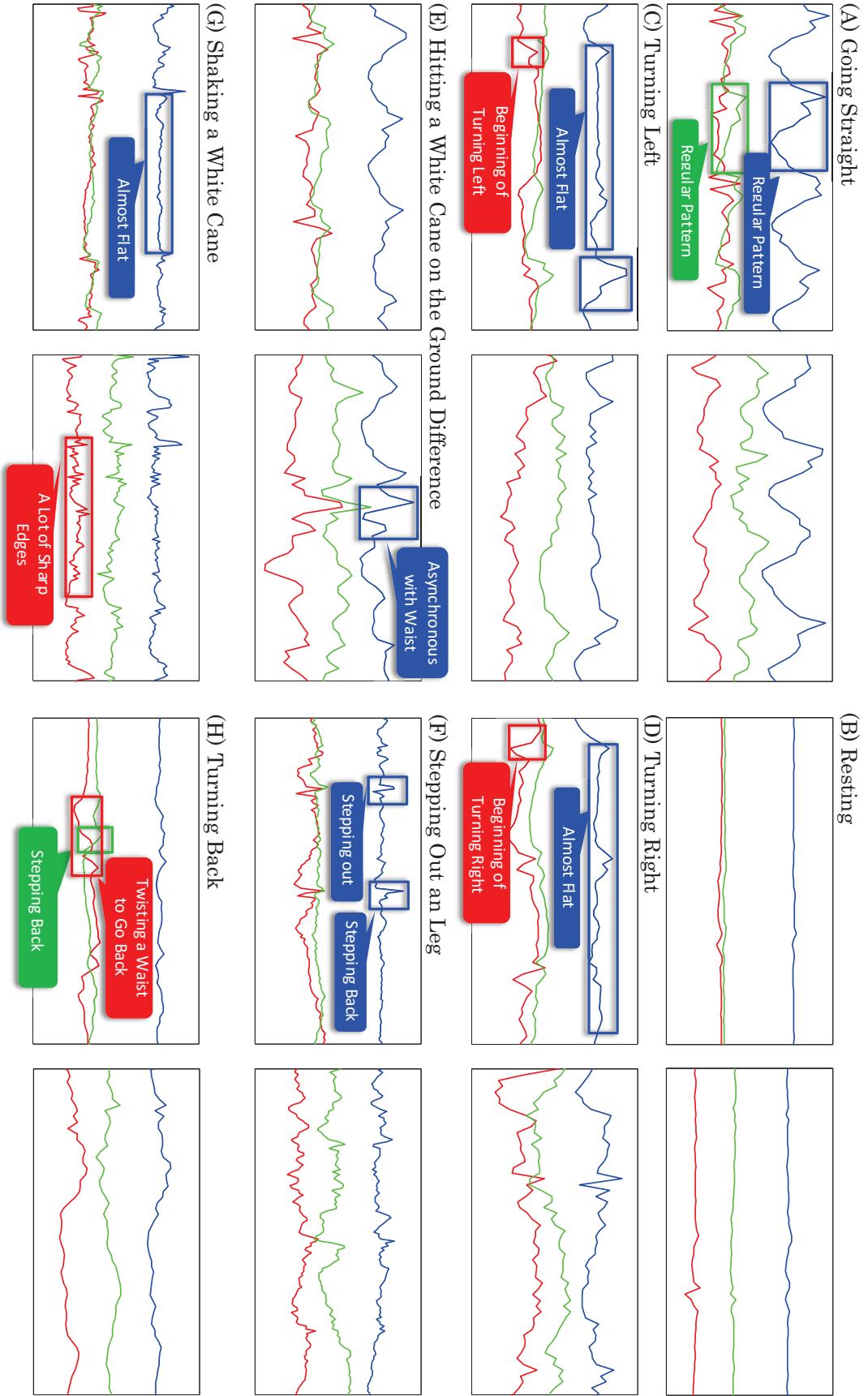


Fig. 3 Acceleration signals of some Activities: (A) going straight, (B) resting, (C) turning left, (D) turning right, (E) hitting a white cane to the small differences on the ground, (F) stepping out one leg to check environment, (G) shaking a white cane, (H) turning back the way he has come. Left side of each pairs of graphs illustrates waist sensor's acceleration signals, and right side illustrates arm sensor's acceleration signals. Red: horizontal direction, Blue: vertical direction, and Green: traveling direction

- (C). Turning Left
- (D). Turning Right

When visually impaired people turns the direction, they suddenly speed-down and twists their waist because they mainly uses tactile indicators to notice the junctions. This action clearly appears in acceleration signals as low acceleration values in the horizontal direction and a big change in the vertical direction. This pattern isn't shown in turning of people without visually impairment because they can change direction smoothly. Furthermore, we can observe an difference between turning left and turning right. When he turned left, acceleration values were change to positive, and when he turned right, the acceleration values were change to negative as shown in Fig. 3-c and 3-d. So, distinguishing a turning left and a turning right is possible by acceleration signals.

(E). Hitting White Cane on Ground Difference

In usual actions like walking, acceleration patterns of the arm sensor were almost synchronized with that of the waist sensor. However, when a white cane hits on ground or was caught on tactile indicators, high acceleration values appear in the horizontal direction of the arm sensor asynchronous with acceleration values of the waist sensor. Acceleration signal notices us even these small issues.

(F). Stepping out and Back one leg

(G). Shaking White Cane

(H). Turning Back

In the experiment, he took three characteristic actions when he got lost and searched direction. Fig. 4-f, 4-g, and 4-h shows acceleration signals of these three actions: stepping out and back one leg to check the environments, shacking his white cane, and turning back the way he came. At first glance, these acceleration signals are obviously different from acceleration signals of usual actions. Thus, developing usual actions' corpus is an effective method to recognize these kinds of unusual actions. Also, these actions have some features in acceleration signals: an acceleration pattern in the vertical direction of the waist sensor which is similar to an walking signal simultaneously with the timing when he stepped out and stepped in (Fig. 4-f), a lot of sharp edges in the arm sensor's horizontal direction (Fig. 4-g), and negative edges in the vertical direction correspond to a step back action and acceleration pattern of the horizontal direction of the waist sensor correspond to twist his waist (Fig. 4-h). However the feature is slight, so we need more investigation.

2 Human Identification

This section is dedicated to illustrate preliminary life-log analysis of human identification. Distinguishing and identifying person is also important factor to help visually impaired people because they have various attributions and

so what support is efficient or necessary is highly depend on people. Identifying person's attribution enables us to know who need support, what kind of support, and how degree of the support is required, and then to provide proper support.

Fig. 4 illustrates arm sensor's signals of four different subjects, P5, P7, P3, and P1 respectively. Each signals were clipped our two sec from their walking signals. The comparison let us know variety of acceleration signals, i.e., each subjects' acceleration signal is totally different at least in first glance. However, with focusing on the horizontal direction (red line), graphs are classified into two groups by if the signal has regularity or not. In top two graphs, Fig. 4-a and Fig. 4-b, the regular pattern aren't observed. In contrast, although each pattern is different in P1 and P3, regularity surrounded by box shape is appeared repeatedly.

Then, question is what causes the differences. Actually, these four subjects are classified into the same two groups be walking type. When they walk, there are two types (and combination of two type) to check environments. First type is leg type. The person who belongs this group, such as P5 and P7, use their legs to search around. Second type is white cane type. Who belong the type mainly uses their white cane to grasp surroundings. P1 and P3 belong the type. The reason of the regularity is the movement of arm to search around. Actually they shake their white cane regularly when they need to find the tactile indicator and follow it. On the other hand, P5 and P7 use their legs and don't use their white cane so much, so the regular pattern wasn't observed.

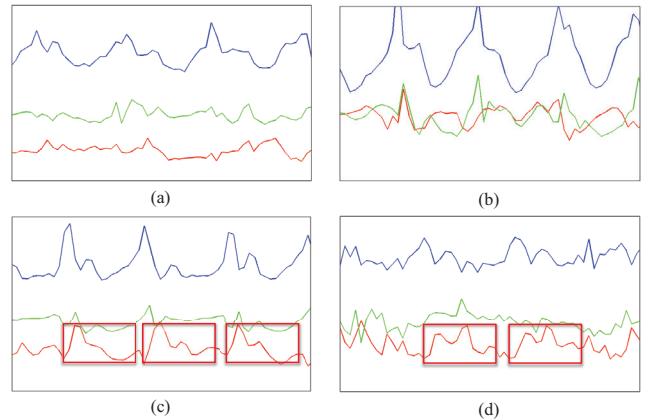


Fig. 4 Captured acceleration signals of arm sensor between four subjects (2 sec), (a) subject P5, (b) subject P7, (c) subject P3, and (d) subject P1. Top two subjects mainly use their legs to check environments, and bottom two subjects mainly use their white cane. Vertical axis: time[s], Horizontal axis: acceleration value [m/s^2], Red line: horizontal direction, Blue: traveling direction, Green: vertical direction

The differences seem to be not so important for some reader, but the result imply important meaning, because

some persons change their walking style depending on the situation. For example, subject P5 used a white cane to check environments under low stress situation, but used their legs under stressful situation. That's mean, his/her mental state changes their actions in greater or less degree, and the change can be detected with life-log signals.

Conclusion and Future Work

In this paper, we proposed our system to support visually impaired people' walking with wearable devices, and investigated their walking with acceleration signals. Our system purpose to recognize visually impaired people's daily activities, and make the map that illustrates uncomfortable points to reduce physically and mentally stress in mobility. The investigation on our original walking life-log shows differences between usual actions and unusual actions, such as getting lost, with simple observation in raw data level. Also, in a viewpoint of human identification, difference of acceleration signals in walking type was investigated. The result implies life-log data also enable us to detect his/her feeling by observing changes of activity. Developing usual actions' corpus and deeply investigations are next steps. As a future work, we are plan to do following three things: 1) searching the feature that indicates characteristics of usual activities well, 2) deeply investigating and comparing acceleration signals of walking between low stress situation and stressful situation, 3) classifying their activities using well-known classifier such as SVM, HMM, or Naive Base Classifier.

Acknowledgements

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References

- [1]. K.Aizawa, G. de Silva, M. Ogawa, and M. Saito, 2010. Food Log by Snapping and Processing Images. *Proceedings of 16th International Conference on Virtual Systems and Multimedia*. pp 71-74
- [2]. Y. Fukushima, et al., 2011. Sensing Human Movement of Mobility and Visually Impaired People, The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility, pp 279-280
- [3]. Y. Iwasawa, and I.E. Yairi, 2012. Life-Logging of Wheelchair Driving on Web Maps for Visualizing Potential Accidents and Incidents. In *Pacific Rim International Conference on Artificial Intelligence*, 2012
- [4]. T. Miura, et.al, 2012. Barrier-free walk: A social sharing platform of barrier-free information for sensory/physically-impaired and aged people. *IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, pp 2927-2932
- [5]. S. Park, 2007. An electronic aid for a visually impaired person using an ultrasonic sensor. *The Proceedings of Digest of Technical Papers International Conference on Consumer Electronics*, pp 1-2
- [6]. I.Ulrich, and J. Borenstein, 2001. The GuideCane-applying mobile robot technologies to assist the visually impaired. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*, vol. 31, pp 131-136
- [7]. Y. Lee, et al., 2012. Adaptive power control of obstacle avoidance system using via motion context for visually impaired person. *The Proceedings of the Cloud Computing and Social Networking (ICCCSN)*, pp 1-4
- [8]. D. Guan, et al., 2011. Review of Sensor-based Activity Recognition Systems, *IETE Technical Review*, vol. 28, p 418-433
- [9]. I. Kawano, et al, 2004. Japanese Experimental GPS Augmentation using Quasi-Zenith Satellite System (QZSS). *The Proceedings of the 7th International Technical Meeting of the Satellite Division of The Institute of Navigation*, pp 175-181
- [10]. E. Farella, L. Benini, B. Ricc' o, and A. Acquaviva. Moca, 2007. A low-power, low-cost motion capture system based on integrated ac- celerometers. *Advances in Multimedia*
- [11]. G. Ogris, T. Stiefmeier, P. Lukowicz, and G. Tr" oster, 2008. Using a com- plex multi-modal on-body sensor system for activity spotting. In *ISWC*
- [12]. A.Zinnen, U.Blanke, and B.Schiele, 2009. An Analysis of Sensor-Oriented vs. Model-Based Activity Recognition. *Proceedings of International Symposium on Wearable Computers*, pp 93-100]
- [13]. U. Maurer, A. Rowe, A. Smailagic et al., 2006. eWatch: A Wearable Sensor and Notification Platform. *Proceedings of International Workshop on Wearable and Implantable Body Sensor Networks*, pp 142-145