The Mobile Sensing Platform: An Embedded Activity Recognition System

SUMMARY

The paper starts off by conferring the underlying problems in detecting activities using a Mobile device and maintains that wearable device can prove to be better approach for the same. The wearable systems have the benefit of being with the user always for e.g. a watch. But at the same time these wearable systems should be able to distinguish the variety of activities for a variety of people. The placement of multiple different type of sensors in a single wearable system is as and sometimes even more efficient as compared to the repetition of a single type of sensor across multiple locations on the body. This replication of a single sensor can be obtrusive as well may not be as efficient in distinguishing between the activities for example sitting and reading a book and sitting and watching TV. In a scenario of watching TV a single sensor such as the accelerometer won't be able to differentiate it with just sitting and talking to someone else but on the other hand a combination of microphone, ambient light sensor and accelerometer will be efficient in this case.

There is a discussion of Wearable Hardware platform, learnings from that hardware platform and subsequent changes to next iteration of same hardware platform based on the learnings from the previous one. In first iteration of Wearable hardware platform they had a number of sensors embedded into it and was capable of running for 10-12 hours. But there were some learnings from this which they discuss:

1. The device had no local storage and used to transfer data to the PDA's or mobile phones either through a Bluetooth or through a USB cable connection. It had two impacts, first was with the continuous use of Bluetooth the battery backup reduced to a time of 4-5 hours as compared to 10-12 hours. This resulted in the hassle of carrying the PDA's connected to the Wearable hardware platform all the time through a USB cable for the transfer of data.
   Second problem was the Bluetooth connectivity was not reliable enough to transfer data continuously to the phones.
2. It was realized that storing and processing the data locally was a better approach as compared to continuously transferring it. Also, further applications that react based on a set of sensor readings required the local classification of the data. This required enough computational power and storage.
3. Recording of complete audio from microphones were also a breach of privacy and were not required. Therefore, it was required to process incoming audio data and keep only the required parts to infer whether a conversation was going on or not.
4. There were issues of the battery of phones and PDA's running out quickly as they were meant for periodic uses and not continuous uses of transferring data.
5. There was no way to determine the geographical location of devices. Geographical locations can also help to distinguish between two similar activities for example sitting in a boat and sitting in a coffee shop.

Based on the learnings of earlier version there were some changes in the next iteration of Wearable Hardware platform which dispensed those problems:

1. Next iteration provided for a removable MicroSD card slot which could be used as the local storage for storing various sensor readings.

2. 3D magnetometers, 3D gyros, 3D compass and USB host were offloaded to a separate daughterboard.
3. The second generation had a larger battery and a much more capable processor to perform some level of computations.

The classification of activities based on data collected from various sensors requires the extraction of various features. The manual training of the systems to detect and differentiate between activities takes a lot of time and effort. Classifiers trained with a small amount of test data are not as reliable in the practical world. But on the other hand acquiring the amount of data required to properly train the models in itself is a big challenge. To counter these two problems, the approach based on boosting was implemented for MSP. This technique selects a small subset of useful features. The trained system outputs the probability for various activities that are possible with those feature sets and selects the one with the highest probability. Results were encouraging based on the results with Inference 3.0(temporal information, semi supervised) giving 83.1% and 87.4% accuracy with 20% and 40% labeled training data respectively.

CRITIQUE

The writers accurately identify the problem associated with devices like mobile phones and advocate the use of Wearable Systems for a better tracking and classifications of the activities. The problem with the mobile devices is that they cannot be always with the person. They were also able to identify most of the problems with the first version of their MSP(Mobile Sensing Platform) like the unavailability of the storage, not having to do certain basic computations on the device, more battery consumption due to the continuous transfer of data from the system to the mobile phones and devices for storage over Bluetooth and collecting more data in case of microphone or less data like in the case of geographical locations then is required to classify the activities. They improved upon such things and were able to get a more reliable and better MSP in the second iteration. The improved design also had certain shortcomings which they were aware of like being bigger then something people would be comfortable to carry.

Still in my opinion there were certain problems with the next iteration which they failed to spot like the inclusion of ZigBee radio for communication in addition to Bluetooth (RFCOMM and PAN). This in my opinion was unnecessary as the modules for communicating are the ones which use the most power and thus drain the battery. It's better to have a single communication mode that works perfectly instead of 2-3 which consume unnecessary power. It was just a redundancy in communication modules in my opinion.

Also, the problem of battery draining very fast in the first iteration due to continuous transfer of data though Bluetooth and unreliability of the Bluetooth connection is something I expected them to be aware of. At the time when this paper was written Bluetooth was still in the early phases and though better than any other mode of communication for shorter distances still consumed a lot of power as compared to battery capacity of the time. Also, their assumption that some other device will always be in the vicinity to receive the data from the Bluetooth signal of the MSP seemed to be impractical. In today' scenario as well this is hardly possible to have your phone with you 100% of the time. 8-9 years back I can't imagine this to be the case which is also reflected by a paper that we discussed in the previous class which says that according to a study in 2006 people had their phones in the same room only around 70% of the times. So not including storage in the MSP in the first iteration seemed to be an impractical decision to me.

Another problem with the second iteration of the MSP was the size and the placement of it. In my opinion placement of such a sensor rich device around the waist is a wastage of the sensors as it won't be able to pick up all the movements of the individual. To properly identify and classify the activities of an individual it should be somewhere on the body which is a part of almost all the activities like hand. Though the technology was not so advanced so that they can fit everything inside a smartwatch like small device but still they could have it on bicep or upper portion of the arm which has relatively more chances of picking up a motion as compare to waist region.

Apart from this there is mention of the unavailability of the geographical location of a user in MSP 1.0, which if available might help identify the location and help in classifying the activities of an individual much better. But nowhere it is mentioned that whether such a capability was included into the MSP 2.0.

Also, there are minimal details on the 3rd iteration of the MSP that they had detailed. There is no mention of the changes on the hardware side as to what all modules were removed or added and how much the size was decreased. What all problems of MSP 2.0 they addressed in the MSP 3.0 on the hardware side? This to me seems something that should have been included.

Apart from this there is not proper mention about the real world results and accuracies of the MSP. There are no measured parameters to judge how good they performed and under what test conditions. In case of training by boosting techniques some numbers are mentioned but the scenario of testing is not mentioned. There should have been a bit more focus on the results especially in the real world scenarios.