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Title of the Abstract: A non-invasive shoe based sensory system to link physical activity level and environmental factors affecting human health.

Theme / Application Area: Wearable Technology / Health care and Wellness

Abstract:

Advances in sensor technology, signal processing, and pattern recognition techniques in hospitals provide the ability to measure physical activity levels of a human being. However it will be nice to have a physical system with the user to constantly monitor the fitness and activity levels, thereby preventing unavoidable health problems. A robust smart system needs to be designed with a group of non-invasive sensors to determine the activity levels of a person and suggest precautionary steps. It has been studied that longevity of a person resides in a recreational area including natural habitats and pollution free ambience. Also, recent studies done by the Association of Ambient Air Pollution and Physical Inactivity in the United States stress on the relationship between physical inactivity, ambient air pollution and obesity. Hence considering the extent of exposure to air pollution as well as activity levels helps in monitoring the healthy state of a person. When individual-level activity and environment statistics are integrated at the level of communities, the resulting data can provide feedback to both individuals and local governments. Individuals can benchmark themselves against others. Local governments can identify regions prone to low physical activity and high pollution levels, and take necessary precautions before leading to serious health impacts. In our prototype, different physical activities are determined with multiple sensors including accelerometers, and pulse sensors. The activity data is correlated with environmental markers determined by noise and pollution sensors. The physical wearable system is designed in the form of shoe based device with a wireless data logging facility. The wearable device offers information in the form of levels of physical activities.

These activities are classified to four levels: sedentary, vigorous, walking and commuting. The environmental markers are arranged into four different types: fresh, low, moderate and high polluted space. At the end of the day, an inference is drawn, which will help the users to improve their health index in the future.

What do you think is innovative or novel about your project? You may highlight the merits of your project, and specific relevance in the Indian context, if any.

The novelty lies in the two main contributions of our prototype. Firstly, in designing a shoe-based wearable device that can monitor not only the physical activity levels but also the effects of environmental factors on a person. Secondly, in recording the exposure levels along with the physical activity levels of a group of individuals directly from the sensors, instead of using individual self-reported survey data. This recorded data can be used in developing an index to determine the consequences of environmental pollution and physical inactivity on a person's health.

Researchers have carried out studies related to monitoring of posture allocations and activities which enable accurate estimation of energy expenditure [1]. Also, extensive studies have been done on the effect of air pollution on human health [14]. Our prototype can be used to provide data that can establish the link between the two lines of research that has also been a topic of exploration in the National Air Quality Conference, Durham [17].

In India for the past few years, efforts have been made to improve the healthcare facilities in the rural areas. Though rural healthcare is a serious issue, urban health care cannot be neglected. Despite the healthcare facilities available in urban areas, greater efforts need to be put in maintaining healthy lifestyle as the urban areas are at the higher risk due to increasing urbanization and increased pollution leading to unavoidable health problems. This low cost system will help individuals and government to take necessary precautions for maintaining the public health.

What are the existing solutions available in market today (provide specific URLs)?

FitBit FLEX, Nike fuelband and the JawBone's UP is wrist band devices that tracks steps, distance and calories burned. During the night time, it tracks the sleep quality of an individual. The Magellan Echo Watch provides information about distance, pace and heart rate, which is user friendly, during physical exercise. Extensive work has been done by countries like Canada and Hong Kong in monitoring the air pollution levels region wise and they compute the health risks using the Air Quality Health Index (AQHI).

Developing a device that monitors both physical activity and pollution levels would provide greater insights into the health of a person. The biofeedback system developed in the form of wearable shoe based device will suggest the person to restore the health index in the future.

What is the work done so far? Please provide specific results/prototype you have obtained/done till now.

Air Quality Sensor was calibrated to measure four levels of pollution that are Pollution free, Sparsely Polluted, Moderately polluted and Highly Polluted. Each of these levels would require a specific course of action to be taken.

Accelerometers, attached to the shoe, were calibrated to differentiate between static and dynamic physical activities. The accelerometer data along with the data from the pressure sensors were used to further classify the physical activities into sedentary, walking, vigorous and commuting.

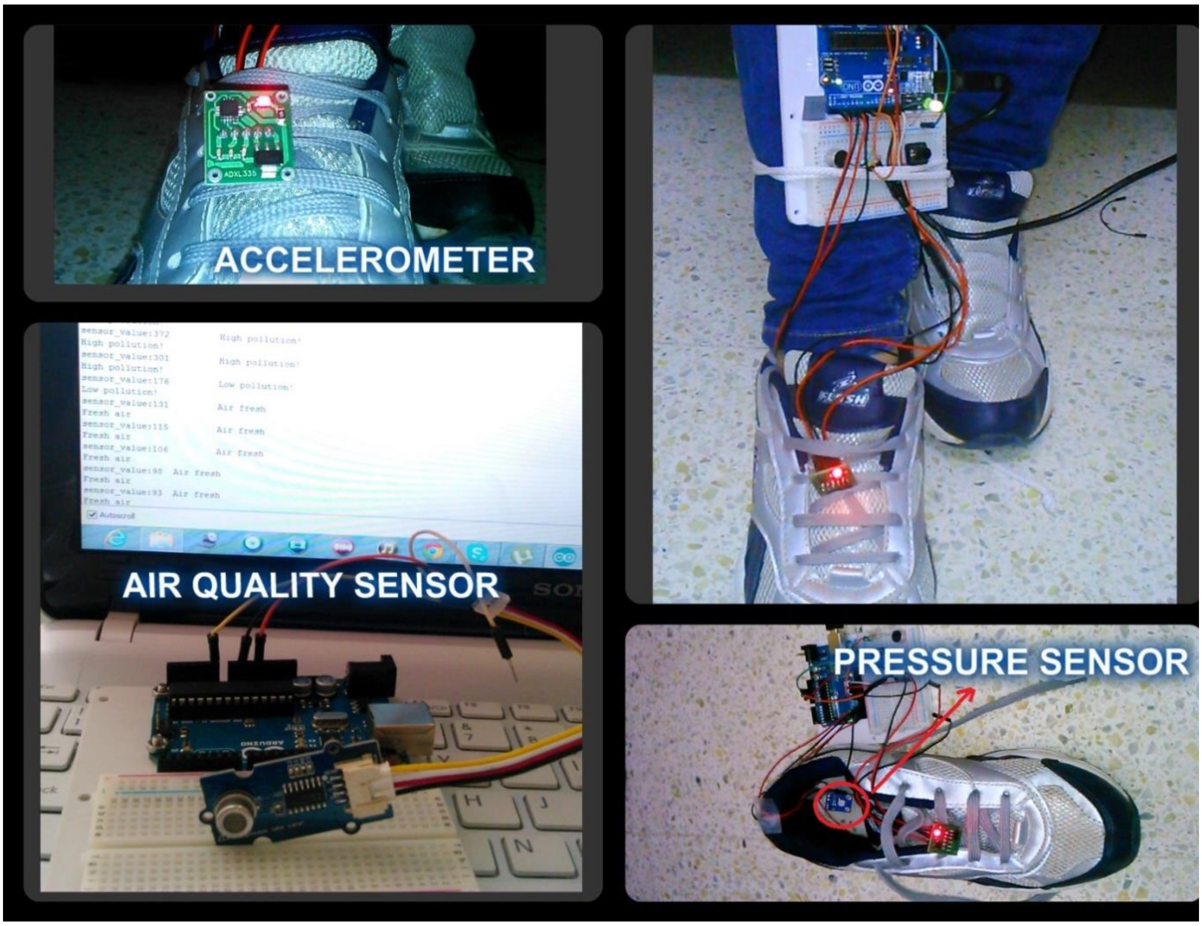

Figure 1: Shows the various sensors to measure the health activity of a person in a shoe based device. This work was carried out by us at the HiDES lab in IIIT-Bangalore.

Sedentary or Low intensity activities like sleeping, watching television, desk work can be determined when the pressure sensors and accelerometer values do not vary much. These activities have a metabolic equivalent of a task (MET) less than 3.0. Walking at different paces has a MET ranging from 3 to 6. The pace at which the person is walking can be determined by pressure sensors and accelerometers. Vigorous activities or the High intensity activities involve bicycling, jogging, running and skipping. Their MET ranges from 6 to 10. Using the MET the calories burnt in a day can be calculated, provided the physical activity can be recognized using the accelerometers and pressure sensors. The calories burned, for activities which cannot be recognized by the sensors, can be calculated using equation (1) as mentioned below.

$$Energy\ Expenditure = gender \times \big(-55.09 + (0.63 \times heartRate) + (0.19 \times weight) + (0.20 \times age)\big) + (1 - gender) \times (-20.40 + (0.45 \times heartRate) - (0.13 \times weight) + (0.07 \times age)) \quad \ldots (1).$$

Here, gender takes the value 1 for males and 0 for females.

The Table 1 shown below is the report generated at the end of the day using the data. Software to generate this table using the measured data from the wearable device needs to be developed.

Table 1: Daily information on health and environmental activity for a group of individuals is recorded in a table form.

Gender		Age	Weight	Physical Activity				Environmental Quality		Inference
M	F			Sedentary	Walk	Vigorous	Commuting	Air Quality	Noise Levels	

When did you start your project & what is your plan for completion?

The work was started in the beginning of May. So far we have conceived the concept, carried out literature survey and performed a few basic calibrations and experiments with the sensors. Among the tasks that need to be done is calibrating a microphone to measure the noise level of the surroundings. Also work needs to be done to increase the accuracy of detecting physical activities by measuring the pulse rate. A faster pulse rate along with acceleration would confirm vigorous activity.

We will test the prototype and record the data collected from a group of individuals by August. We would require Intel Galileo board to measure the real-time activity and environmental data of the human beings, and to wirelessly transfer the densely sampled data of sensors to a repository unit. The processing of the data to infer the activity levels and ambience levels is performed remotely.

Please provide in brief, any additional information for consideration of your project to next level? (You may include your specific expertise, skill set, past innovation etc.)

We have expertise in electronics, programming, data structures and signal processing through projects and formal courses as a part of our curriculum. We have worked on Arduino platform for an electronics project. The aim of the project was to develop a Solar powered traffic control system [18]. The project involved integrating together a solar panel, a rechargeable battery, a 22x4 LED display, and LEDs for traffic lights. The figure2 shows various aspects of our project.

We are guided by two able faculty members, Prof. Madhav Rao (PhD: University of Alabama) and Prof. Dinesh Babu (PhD: Ecole Polytechnic Federale Lausanne (EPFL)). We are also in touch with Fields of View (FoV), a non-profit organization, who are working with city planners and civic agencies, to get a realistic feedback about our project and future course of action.

Figure 2: Solar powered traffic control system at an intersection [18].

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