Measurement of Dynamic traits: Analysis and Significance of Techniques

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ABSTRACT

Inquisitiveness and eagerness to emerging techniques of wireless sensor networks have made things beautiful. This paper focuses on the dynamic traits of a person.A deep survey of the existing literature is done and then special scenarios possible with the sensors are presented to easily pave the way for future research. To have knowledge of various movements specific to moving objects especially humans is necessary and a Subject of interest. Research is going at a low pace & implementation models tend to show poor performance. This paper aims at delineating the various methods of detection using various sensors. Different problems are a part of every research and these are presented in this paper. The overall goal of this paper is to compare the reliability of the various parameters whether used for classification of targets, or any other quantitative phenomenology in dynamic trait analysis.

KEYWORDS

Dynamic traits, Sensing, motion, reliability,detection.

I. INTRODUCTION

Dynamic traits are solely dependent on the human activity. Wide range of motion is exhibited by a human, animal or any other physical moving object. To study this motion; detect it and analyze it is issue of current research. A logical and physical structure of a wireless network makes it easy to initiate the work in this domain.Architecture of a wireless sensor network is shown in fig 1. To be precise, wireless sensor networks consist of autonomous devices that are capable of sensing any changes according to the properties of the inherent components. While building various systems for dynamic trait detection, it is important for the system to possess at least the following properties:

1. Compactness and simplicity.
2. Use of efficient and optimum priced components so that it is widely available for use.
3. Use of energy efficient and feasible algorithm,
4. System developed should address the current problems as well as aim at solving the possible future problems.

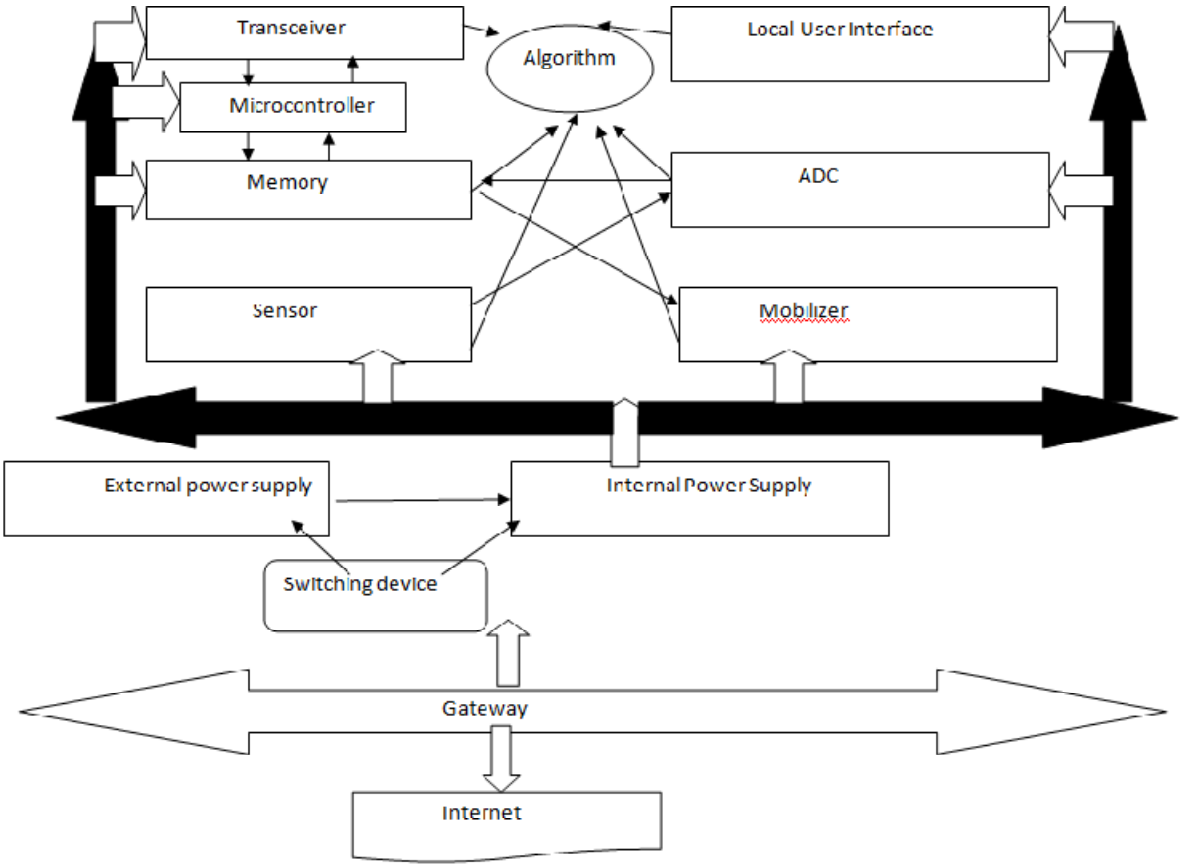

Fig 1. Architecture of a Wireless Sensor Network

The analysis of dynamic traits of moving objects especially humans are done by various methods which are listed in the coming sections.Motion of a moving object may be specialized i.e. involving a large number of complex arbitrary paths or a simple one .A simple motion may be shown by using a right handed orthogonal coordinate system as shown in fig

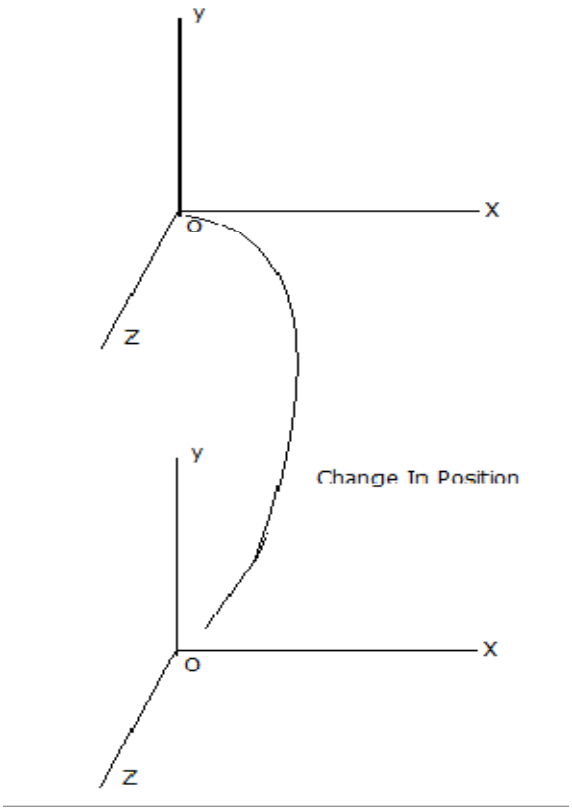

Fig 2. Motion like walking on a road

A more complex motion would require the use of polar coordinates.It is important to note that for a small distance of several meters the motion is apparently straight. Thereafter, the motion tends to be curvilinear.

2. OVERVIEW OF DYNAMIC TRAIT SENSORS

Dynamic trait sensors are characterized by their ability to recognize the various activities involving motion performed by a moving object. A number of dynamic trait sensors exist. Some common ones are tabulated in table 1.

Dynamic Trait Sensors
1. Acoustic Sensors 2. Seismic Sensors 3. Pressure Sensors 4. Motion Sensors 5. Doppler Shift sensors 6. Micro- machined Tunnel Sensors 7. Strain sensors 8. Inertial Sensors 9. Ranging Sensors 10. Thermal Imaging Sensors 11. Tomographic motion detection sensors 12. Cameras

Table 1: Dynamic trait sensors

Sensors of primary interest are : Acoustic sensors: These sensors use a mechanical wave for sensing the change in velocity of a particular object [1].Acoustic sensors are grouped according to their operating frequency as shown in table 2.

	Frequency Comparison	Range
Low	TSM (BAW)	5-20 GHz
Medium	APM	25-30 GHz
High	APM,SAW,SH-SAW	35- 500 GHz

Table 2: Comparing frequencies of acoustic sensors

BAW (Bulk Acoustic Wave sensor) can be used for liquids. For human detection, acoustic sensors can detect the walking of a person by analyzing sounds produced by feet while hitting the ground [2].

Seismic sensors are used to measure motions generated from a surface. Feedback loop especially negative feedback loop is used to keep the relative motion between the mass and the frame of reference to be zero.

Motion Sensors are infrared sensors employed for detection of humans as well as animals. Motion sensors are of two broad types:

1. Passive infrared type (PIR)
2. Area Reflective type.

Passive infrared type detects the variation of IR rays emitted by an entity that possesses locomotion and a difference in temperature from its surroundings. On the other hand area reflective type sensors detect the presence of an object by emitting infrared waves from an inbuilt LED. Optical sensors are simply used to capture the image of an object.

Motion Sensors are characterized by various properties which are delineated in table 3.

Characteristic properties of motion sensors
1. Resistant to vibration: The sensor should be resistant to vibration amplitude, frequency.
2. Resistant to temperature: The sensor should be capable of functioning properly in a wide range of temperature and must thus be chosen according to the temperature need.
3. Resistant to shocks: The sensor should tolerate thermal shocks as well as any other external shocks.
4. Optimum use of power supply: The use of power supply must be moderate.

Table 3. Features of Motion sensors

Yet another important sensor is the micro machined tunnel sensor which eliminates the need for piezoelectric actuators. It uses extreme sensitivity of electron tunneling in-order to build a compact and efficient transducer [3].

Doppler shift sensors work on the principle that if a beam of radiation is directed on the moving objects, the reflected radiation suffers a change in frequency.

Inertial sensors depend on the inertia of the body. They are available in variety of forms such as: accelerometers, gyroscopes etc. They find applications in various fields such as device tracking , ground robotics etc.

2.1 Selection of sensors

Different sensors are characterized by different properties.Before using any type of sensor for dynamic gait analysis it is important to know beforehand the properties of sensors. This aids in minimizing the effort and time for building a sensor network or working model .

The properties of sensors are summarized in table 4.

These properties serve as criteria for choosing the sensors according to a specific situation or scenario. Sensors have been compared on the basis of different properties like external affects sensitivity etc.

Type	Sensitivity to dynamic event along the line of sight	Affect of environmental conditions(ambient conditions)	Signal Processing level
Seismic	No or sensitivity tending to zero	Yes, a slight effect	Variable, between low & high
Magnetic	No or sensitivity tending to zero	Negligible effect	High
Thermal	Yes, considerable sensitivity	Considerable effect	High
Optical	Yes, good sensitivity	Considerable effect especially of weather	High
PIR	Requires a direct line of sight	Mainly affected by temperature	Variable-Low intensity signal can be detected by amplification
Acoustic	Very less sensitivity	Little effect	Medium
Wearable inertial	Depends on range-for small range it is very sensitive.	Considerable effect when the line of sight is disturbed	Medium

Table 4. Variable properties of sensors

2.2 Limitations of dynamic trait sensors

It is wise and important to know the limitations of sensors before employing them.

Limitations of three commonly used sensors are as under:

PIR: Their calibration and installation is difficult. Optimum working temperature is 15-25 degrees Celsius.

Thermal Sensors: Non- linearity, self heating and moisture failures

Acoustic: Attenuation and variable propagation velocity are the major disadvantages of these sensors.

2.3 Major problems in dynamic trait detection sensors

Dynamic trait detection faces a variety of problems. The challenges need to be known in advance for any implementing model to be successful [5].

The problems can be divided into two categories:

1. Inherent problems
2. Borrowed Problems

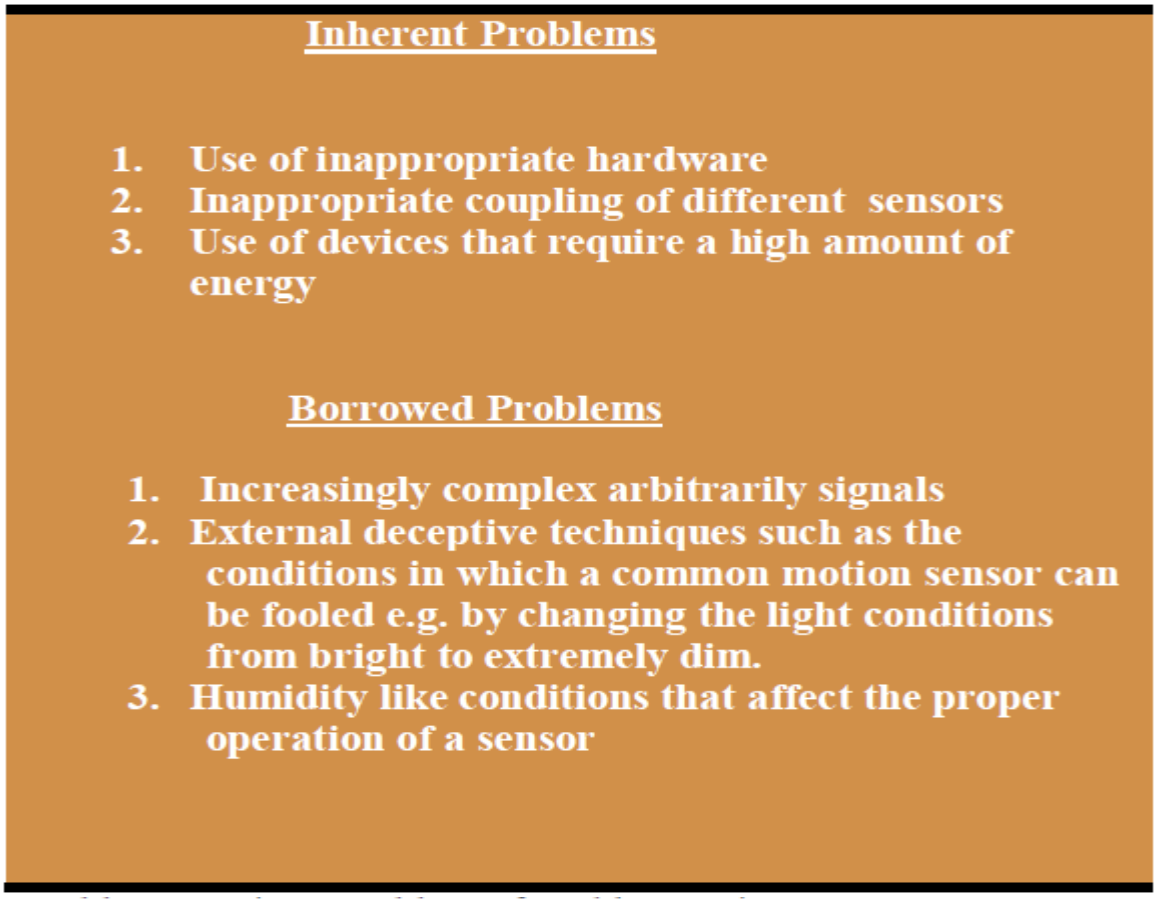

Table 5. Various problems faced by motion sensors

3. TECHNIQUES AND APPROACHES OF SENSING HUMANS

This section focuses on different scenarios used in different applications in detecting human presence by dynamic trait detection sensors.

As specified in "jogging and walking analysis using wearable sensors" [4] a sensor model is built by incorporating three sensors for motion analysis. The sensors used were tri-axial accelerometer, gyroscope and compass. A motion classifications system has been developed in this approach and by others for the same kind of motion analysis. A critical analysis of the system revealed the following drawback:

While analyzing human motion x- axis motion which represents forward jerk has been neglected. Thus, a sudden jerk would yield unpredictable results. It is essential to take this motion into consideration. Further, momentum equilibrium is a very important to consider. If a person or an animal strike with a wall or any other physical object, it suffers a change in its momentum. It is also essential to find the true path of a person. Fig 3 illustrates the difference between true path and the varied path.

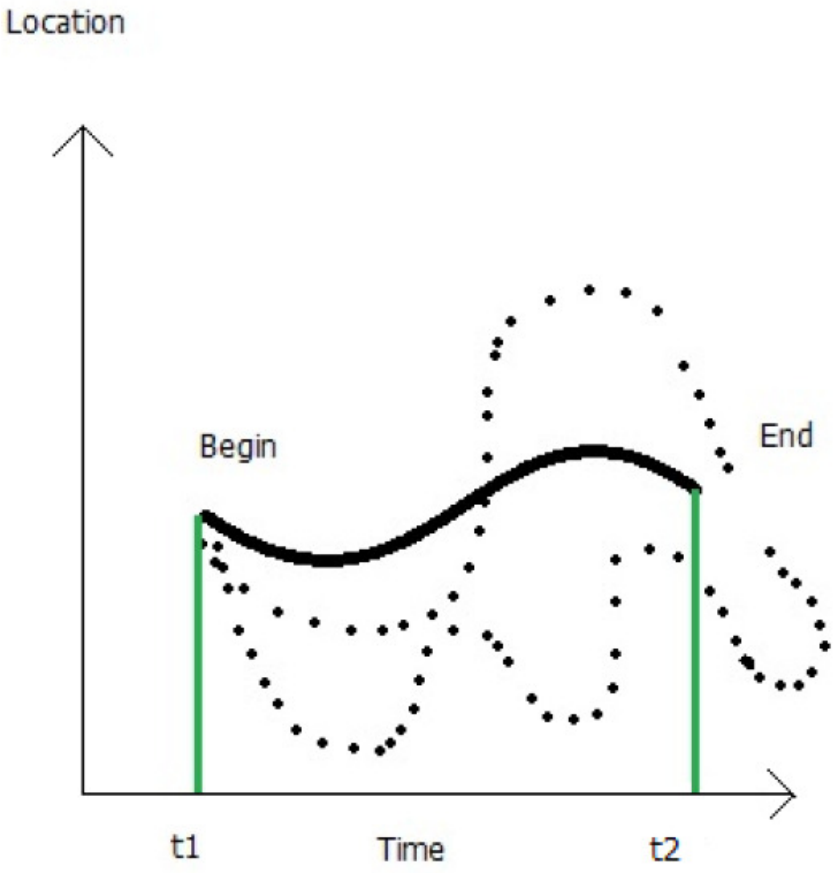

Fig 3. (Dotted lines show varied path & bold line is the true path)

This yields a perfect piece of advice tip" Every model must be carefully examined for false alarms before implementing it".

Next, acoustic sensors have also been used for human presence detection. Experiments show that the uncertainty factor is about 30-40% which can be improved by using various fusion techniques such as fusion of acoustic and ultrasonic sensors, fusion of acoustic and seismic sensors [6]. This would increase the true probability of detection.

3.1 Classification approach

It has been shown in [7] that a classification approach can be used for differentiation between various entities. The entities are labeled as targets. Several parameters have been used for classification such as acceleration, velocity etc. This approach has been widely used for military purposes.

Limitations of this approach

A person, soldier or a vehicle are classified on the basis of velocity, acceleration etc. It is assumed that a person walks with a normal speed while a soldier or a vehicle walks with a greater speed in addition to having metallic properties as in case of vehicle.

A special yet common scenario that arises from the normal psychology or a sudden reflex of a person is delineated under:

A person say robin is walking on a road. Suddenly an armed vehicle passes by and declares emergency situation. A person by his inherent nature will start to run. So, the classification parameter of high velocity for soldier fails. This can prove fatal in war like situations.

3.2 Comparing reliability of inherent properties

A number of inherent properties are considered while dealing with target analyzing and classification. The reliability of these properties shown in table 6.

Some entities like vehicles show high properties due to their high movements possessing high kinetic energy while other entities have properties that are just measurable.

Properties	Reliability	
	Humans/Animals	Machines
Thermal	High	Dependable
Magnetic	Considerable	High
Acoustic	Considerable, movement dependent	Inherently high reliability
Seismic	Considerable	Inherently high reliability
Optical	High	High

Table 6: Reliability of properties in sensing

4. CONCLUSION

The quest of humans for analyzing dynamics is growing day by day. While very specialized methods exists for dynamic trait analysis careful measures need to be taken so as to minimize the effort and important the quality performance. This in turn implies that the properties, reliability and proper application of the sensors must be known in advance for implementing an effective model. Besides, sensitivity is a very important factor to consider while dealing with the sensors. It is at the heart of sensing.

5. ACKNOWLEDGMENT

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