# Smart-Walk: An Intelligent Physiological Monitoring System for Smart Families


P. Sundaravadivel[1], S. P. Mohanty[2], E. Kougianos[3], V. P. Yanambaka[4], and M. K. Ganapathiraju[5]

University of North Texas, Denton, TX 76203, USA.[1,2,3,4]
University of Pittsburgh, Pittsburgh, PA, USA.[5]

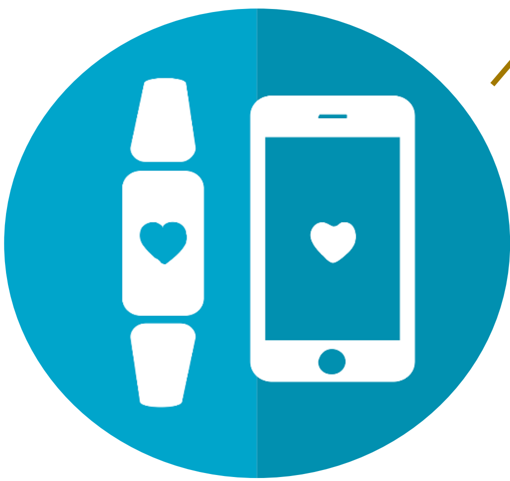
Email: ps0374@unt.edu[1], saraju.mohanty@unt.edu[2], elias.kougianos@unt.edu[3], vy0017@unt.edu[1], and madhavi@pitt.edu[5]

# Outline of the talk

- Introduction and Motivation
- Novel Contributions
- Proposed Architecture for Smart Walk System in IoT
- System level design of Smart Walk System
- Implementation and experimental results
- Conclusions and Future research

# Introduction

## ✓Wearables



**Advantages**
- Enriched user experience
- Personalized remote assistance

**Applications**
- Single condition
- Clustered condition

**Research**
- Pre data acquisition phase
- Post data acquisition phase

Smart healthcare empowers the users to self-manage emergency situations and keep them health-aware.

# Introduction

✓ **Internet of Things**

- The Internet of Things is a network of devices where each device in the network is recognizable and connected.
- It can be thought of as the interconnection of uniquely identifiable smart objects and devices.

# Introduction

- Wearable Requirements
  - Small form factor
  - Connectivity
  - Low power
  - Improved accuracy
  - High efficiency

# Novel Contributions of This Paper

1. An architecture is proposed for vital sign monitoring in families.
2. A dynamic calibration module to improve the accuracy of the sensor design is proposed.
3. A feature based framework for human step-detection based on the learning parameters is proposed.
4. The algorithm is validated using a classifier which analyzes different learning parameters and dynamically calibrates the sensor system.

# Framework of the Smart Walk System

## ✓ Ideal Components

- Sensor/transducer for data acquisition.
- Algorithms
- Information sharing
- Assistance to users

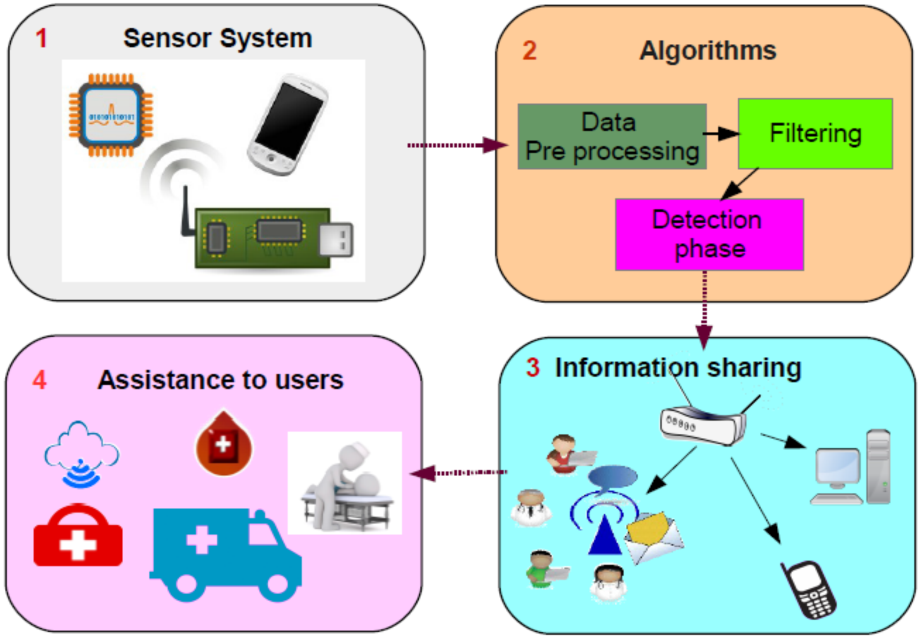
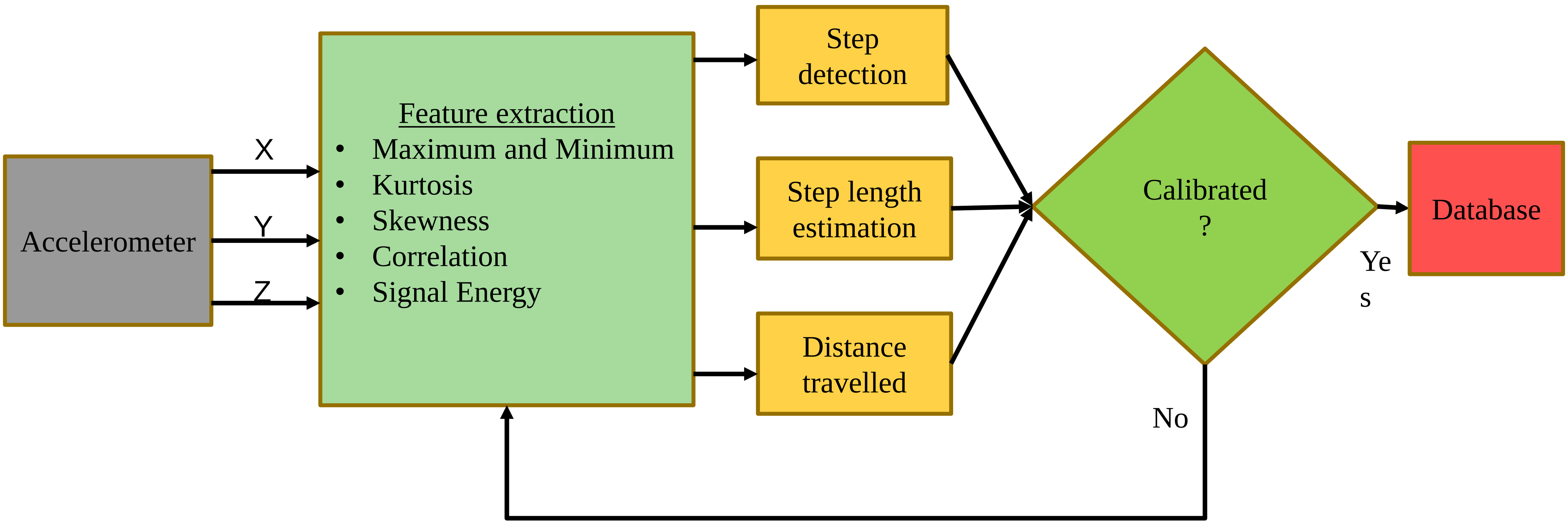



Fig. 2. Framework of the Smart walk system

# Proposed method for Efficient Parameter Estimation



# System level design of Smart Walk System

- ❖ Feature extraction for data analysis
- ❖ Human Activity monitoring Algorithm

# Feature extraction

✓ **Accelerometer data**

- X-axis → twisting or turning
- Y axis → leaning backward or forward
- Z-axis → movement against gravity

✓ **Features**

- Kurtosis
- Mean
- Standard deviation
- Maxima and Minima
- Skewness

# Human Activity Monitoring Algorithm

Step detection

Step length estimation

# Human Activity Monitoring Algorithm

- Step length is measured from heel to heel

- Human step length estimation varies linearly in accordance to the walking frequency and accelerometer variance

$$\boxed{\textit{Step length} = \alpha.f + \beta.v + \gamma}$$

- f → walking frequency
- v → Variance of the accelerometer
- $\alpha$ $\beta$ and $\gamma$ → pre-learned parameters

# Implementation & Validation

- Sensor Design
- Classifier evaluation using WEKA

# Data for the Sensor System

- A public database consisting of 10291 instances of smartphone based human activity data was considered from Kaggle.

- These instances were grouped into six categories of activity: sitting, standing, walking, climbing downstairs, climbing upstairs, and laying.

# Classifier evaluation using WEKA

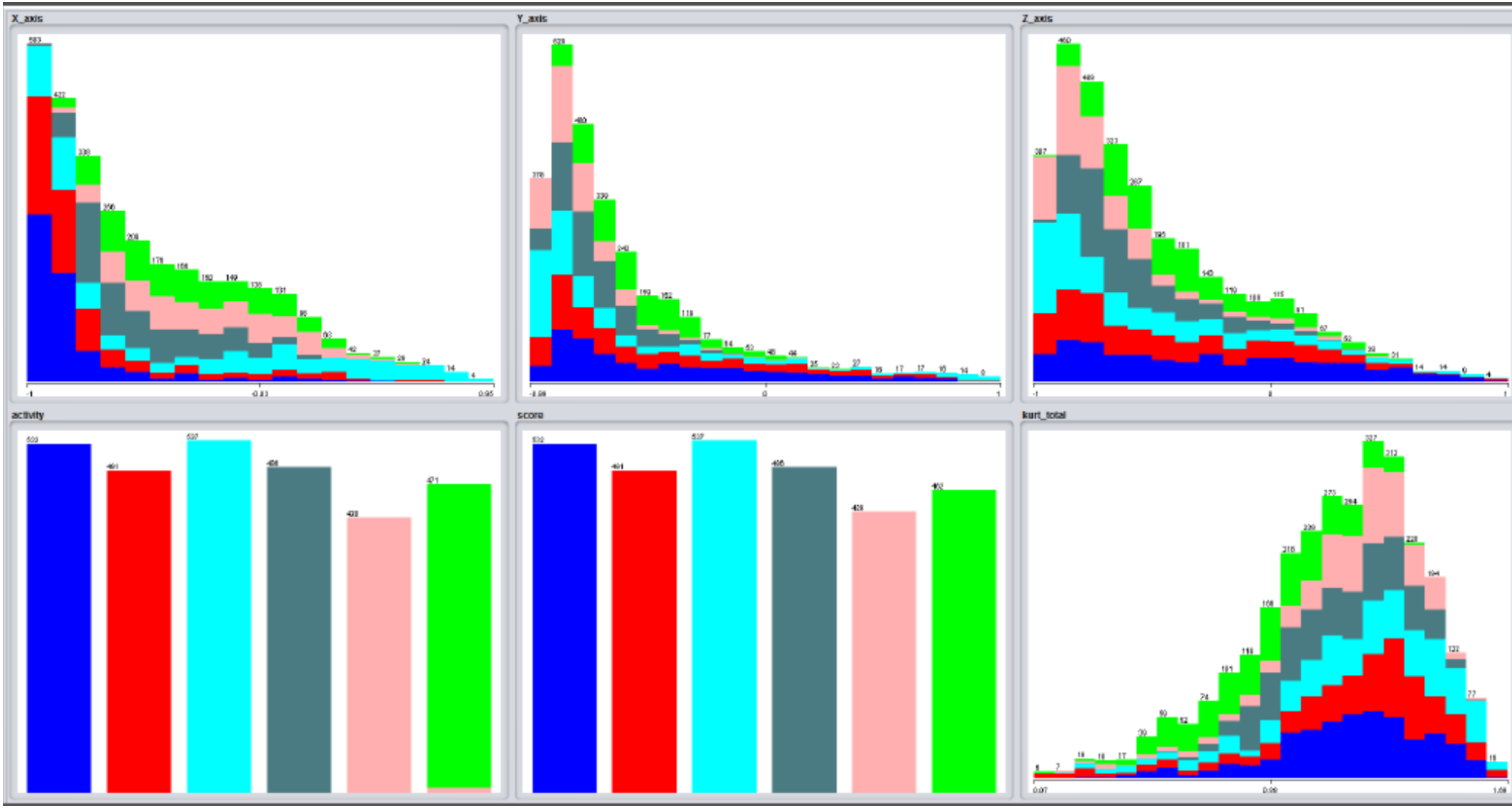
- Waikato Environment for Knowledge Analysis (WEKA) helps in evaluating system using numerous algorithms.

- Whenever a user makes a data entry, an Attribute-Relation File Format (.arff) is created, which serves as input for WEKA.

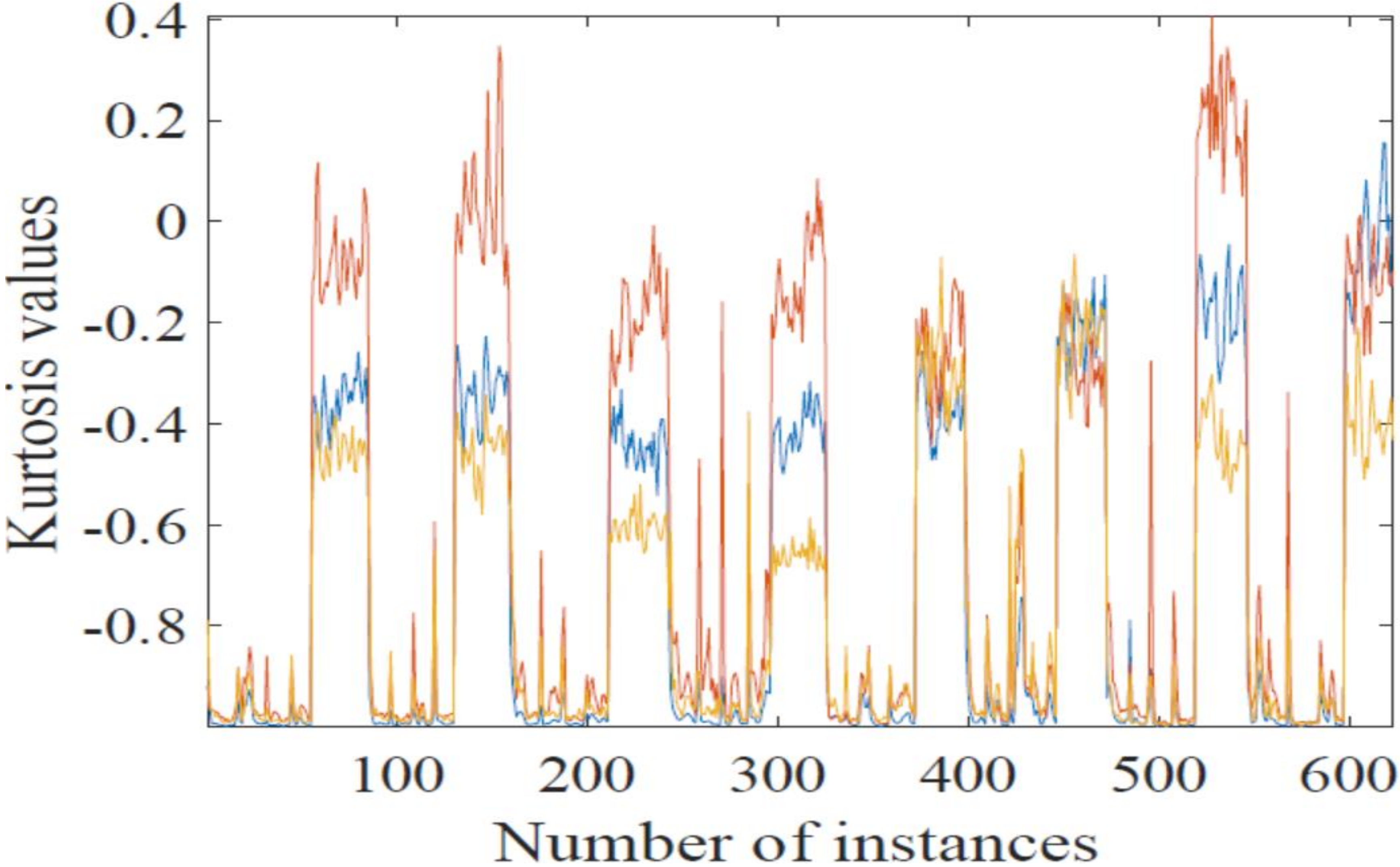
# Classifier evaluation for Kurtosis values using WEKA

| Classifiers | Correlation Coefficient | Mean absolute error | Root Mean Squared error | Relative absolute error(%) | Root Relative Squared error (%) |
|---|---|---|---|---|---|
| SMO Regression | 0.7795 | 0.1029 | 0.1956 | 44.8049 | 67.68 |
| Gaussian Process | 0.7979 | 0.1146 | 0.1742 | 49.90 | 60.28 |
| M5 Rules | 0.9741 | 0.0409 | 0.0657 | 17.82 | 22.72 |
| Decision Table | 0.9263 | 0.0619 | 0.11 | 26.94 | 38.07 |
| Linear Regression | 0.7979 | 0.1142 | 0.1741 | 49.71 | 60.27 |
| Multilayer Perceptron | 0.9645 | 0.0597 | 0.0868 | 26.00 | 30.03 |
| Additive Regression | 0.9273 | 0.0856 | 0.111 | 37.26 | 38.41 |

# Kurtosis Analysis in WEKA



# Kurtosis values in different postures from 3 different subjects



# Classifier evaluation for Minimum and Maximum Accelerometer values using WEKA

| Classifiers | Mean Absolute error | RMS error |
|---|---|---|
| Input Mapped Classifier | 0.0014 | 0.0018 |
| SMO | 0.222 | 0.3089 |
| Decision Stump | 0.2234 | 0.3342 |
| Simple Logistic | 0.0437 | 0.0587 |
| Decision Table | 0.0015 | 0.0002 |
| Bayes Net | 0.0009 | 0.3309 |
| Multilayer Perceptron | 0.0012 | 0.0016 |

# Performance Comparison with Existing Research

| Research Works | Method | Features considered | Activities | Accuracy (%) |
|---|---|---|---|---|
| Shin et al [21] | Awareness algorithm of movement status | Step length and total walking distance | Walk and run | 96 |
| Chien et al. [20] | Dynamic algorithm | Number of steps taken | Walking, jumping and jogging | 95 |
| **This paper** | Adaptive algorithm based on feature extraction | Step detection and Step length estimation | Walking, sitting, standing | 97.9 |

# Characterization Table for the Proposed System

| Characteristics | |
|---|---|
| Sensor System | TIMSP432 launchpad integrated with Educational Booster Pack MKII |
| Operating Frequency | 48 MHz |
| Sensor data acquisition tool | Energia and MATLAB |
| Data Analysis Tool | WEKA |
| Sample Dataset | 10291 instances for analysis and 623 instances for validation |
| Classifier | Decision Table |
| Accuracy (Worst Case) | 97.9% |

# Conclusion and Future Research

- A framework based on features, for human activity monitoring system to keep track of physiological health of friends and family.

- This method helps in improving the overall calibration of the activity monitoring system.

- The decision table classifier using the data acquired from the sensing module yields 97.9% accuracy.

# Thank You !!!

Slides Available at:

http://www.smohanty.org