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NEURAL NETWORK BASED CHILD ACTIVITY RECOGNITION

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ABSTRACT

This paper presents the design of an artificial neural network for the child activity recognition. A Triaxial accelerometer sensor, housed in the leg, hand and back worn sensor unit has been used for capturing the acceleration of the movements associated. All the three sensors acceleration data were collected pre-processed and classified by extracting its features using MATLAB. A neural network approach for classification was used with an eye on Advanced RISC Machine (ARM7) based microcontroller recognition approach. This work shows a detailed description of the designing steps for the child activity classification with the help of acceleration data. A Feed forward neural network, with "trainbfg" algorithm for training, showed better performance when compared with the activity recognition using ARM7 based microcontroller approach. Recognized child activities are monitored and sent messages to their parents through Android mobile phones. Voice alerts are also sent if the temperature goes very high.

KEYWORDS: Accelerometer, Activity Classification, Activity Recognition, Feed-Forward Neural Network

INTRODUCTION

In children younger than four years of age, most fall-related injuries occur at home. Thus, a new safety management method for children is required to prevent child home accidents. Since the major causes of fall-related injuries change as a child grows and develops, fall prevention needs to be addressed. One of the most challenging issues in this context is to classify daily activities of children into safe and dangerous activities. This paper shows the complete designing of an artificial neural network for the classification of Child activity data received from an accelerometer sensor. The work gives a detailed description of designing the topologies of neural network, the selection of various training parameters.Child activity is recognized using Neural Networks which helps us to increase the performance and accuracy of the overall system. Its performance is compared with the activity recognition using Advanced RISC Machine (ARM7) processor. Then Temperature Sensor is to intimate the room temperature of child through GSM and ALCD for display the activities of child, intimation will be sent through GSM and Buzzer gets sounded for alert. Recognized activities are monitored and sent messages to their parents through Android mobile phones. Voice alerts are also sent if the temperature goes very high.

In this paper, sensor technology such as acceleration sensors were used for identifying the child activities such as walking, Standing still, sitting down, toddling, crawling, rolling. Some of the applications of this paper include assisting the sick and disabled children for monitoring their daily activities and for further medication. Sensor based activity recognition provides sufficient sensor data and calculation power to enable physical activity recognition to provide an estimation of the energy consumption during everyday life.

Neural networks take a different approach to problem solving than that of conventional computers. Conventional computers use an algorithmic approach i.e. the computer follows a set of instructions in order to solve a problem. Unless the specific steps that the computer needs to follow are known the computer cannot solve the problem. That restricts the problem solving capability of conventional computers to problems that we already understand and know how to solve.

Neural networks process information in a similar way the human brain does. The network is composed of a large number of highly interconnected processing elements (neurons) working in parallel to solve a specific problem. Neural networks learn by example. They cannot be programmed to perform a specific task. The examples must be selected carefully otherwise useful time is wasted or even worse the network might be functioning incorrectly. The disadvantage is that because the network finds out how to solve the problem by itself, its operation can be unpredictable.

On the other hand, conventional computers use a cognitive approach to problem solving; the way the problem is to solved must be known and stated in small unambiguous instructions. These instructions are then converted to a high level language program and then into machine code that the computer can understand. These machines are totally predictable; if anything goes wrong is due to a software or hardware fault.

Activity Recognition

Neural Networks Based Recognition

For efficient motion pattern recognition of gestures and postures, feed-forward neural networks are adopted. System is designed with the help of feed-forward neural network architecture as shown in figure 1; it is very popular architecture because it can be applied to many different tasks.
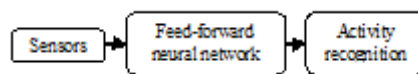

Figure 1: Block Diagram of Neural Network Recognition

Activity recognition is based on classifying sensory data using one or many accelerometers. Accelerometers have been widely accepted due to their compact size, their low-power requirement, low cost, non-intrusiveness and capacity to provide data directly related to the motion of people.

Feed Forward Neural Network

In Feed forward neural networks, the neurons are arranged in layers, with the first layer taking in inputs and the last layer producing outputs. The middle layers have no connection with the external world, and hence are called hidden layers. Each neuron in one layer is connected to every neuron on the next layer. Hence information is constantly feed forward from one layer to the next. There is no connection among neurons in the same layer. Learning in feed forward networks belongs to the realm of supervised learning [1], in which pairs of input and output values are fed into the network for many cycles, so that the network learns the relationship between the input and output. Figure 2 shows the framework of feed forward network.

The neurons in each layer are fully interconnected by connection strengths called as weights. Also each hidden and output layer neuron consists of a bias term associated with it.

The designing of neural network involves the decision in number of hidden layers and number of neurons in each layer along with the transfer functions. In this work MATLAB neural network toolbox has been used for implementation.

Implementation

The objective of the neural network training was to find the weights and biases between the neurons that determine the global minimum of the error function. We have used *trainbfg* algorithm to train the classifier for the classification of child activity data from the accelerometer sensor.

The *trainbfg* is a network training function that updates weight and bias values according to the BFGS quasi-Newton method. Training occurs according to *trainbfg's* training parameters, table 1 shows their default values.

Newton's method is an alternative to the conjugate gradient methods for fast optimization. The basic step of Newton's method is

$$\mathbf{x}_{k+1} = \mathbf{x}_k - \mathbf{A}_k^{-1} \mathbf{g}_k$$

Where $\mathbf{A}_k^{-1}$ is the Hessian matrix (second derivatives) of the performance index at the current values of the weights and biases. Newton's method often converges faster than conjugate gradient methods. Unfortunately, it is complex and expensive to compute the Hessian matrix for feed-forward neural networks. There is a class of algorithms that is based on Newton's method, but which does not require calculation of second derivatives. These are called quasi-Newton (or secant) methods. They update an approximate Hessian matrix at each iteration of the algorithm. The update is computed as a function of the gradient. The quasi-Newton method that has been most successful in published studies is the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) update. This algorithm is implemented in the trainbfg routine.

The BFGS algorithm requires more computation in each iteration and more storage than the conjugate gradient methods, although it generally converges in fewer iterations. The approximate Hessian must be stored, and its dimension is n x n, where n is equal to the number of weights and biases in the network. For very large networks it might be better to use one of the conjugate gradient algorithms. For smaller networks, however, trainbfg can be an efficient training function. *trainbfg* can train any network as long as its weight, net input, and transfer functions have derivative functions.

Training stops when any of these conditions occurs:

- The maximum number of epochs (repetitions) is reached.

- The maximum amount of time is exceeded.

- Performance is minimized to the goal.

- The performance gradient falls below minimum gradient.

- Validation performance has increased more than maximum fail times since the last time it decreased (when using validation).

MATLAB provides the default values for some of the parameters involved in the design of neural network [2]. An empirical approach was used to decide for modifying the parameter values for the designing of the neural network. The values of parameter used in our design are shown in table 1 with a brief description of each of the parameter.

Transfer function of any layer determines its output. A sigmoid function 'tansig' was used as a transfer function for each hidden layer in the network. The sigmoid function is a nonlinear and continuously differentiable function. It can convert an infinite range into a finite one and hence prevent outputs from reaching very large values which can inhibit the training process.

The error function defines the evaluation criterion. We chose a mean squared error function 'mse' as an evaluation criterion. It minimizes the mean of the squares of the errors produced in each iteration and updates the network weights and biases accordingly. The performance goal for the training is decided using this error function only. The value of goal parameter for 'mse' is shown in table 1.

Table 1: Training Parameters of Neural Network

Parameter	Default Value	Description
epochs	500	Maximum number of epochs(repetitions) to train
goal	1E-4	Performance goal

ARM7 Based Recognition

Here microcontroller is the heart of project, which controls all the components in the project shown in the figure 3. To observe the child and show all the activities of the child in home, we are attaching accelerometer and Radio Frequency Identification(RFID) card, where accelerometer detects child present and falling stages through its axis and RFID card will be read by RFID reader which is attached to table or bulky Items, when the child move towards a table or bulky material which can be harmful to child, so to avoid this, Buzzer is used to sound when child come towards harmful objects and GSM for getting message to their parents/guardians for take care, where the parents/guardians Mobile consists of Android application to graph the child activities.
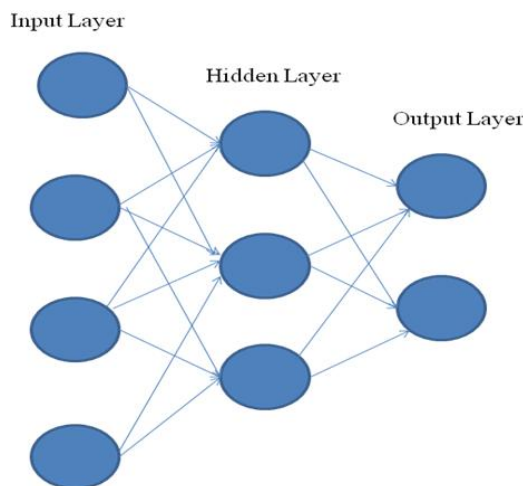

Figure 2: Typical Feed Forward Neural Network

Then Temperature Sensor is to intimate the room temperature of child through GSM and A LCD for displaying the activities of child, intimation will be sent through GSM and Buzzer gets sounded for alert. The activity of the child in the home will be monitored and sent to Android Mobile through GSM, then the information will plotted through graph in Android Mobile and also security alert or voice output will be generated through android when child in danger.

In this project the child activities are graphed under six stages in android Application through information got from model to mobile such as rolling, standing still, sitting down, walking, toddling, and crawling. LPC2103

microcontroller from Philips is used to implement this project. This project can be shown through connecting sensors to our own body or Toys at the demo time.

Accelerometer

The ADXL335 is a complete 3-axis acceleration measurement system as shown in figure 4. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration [3].
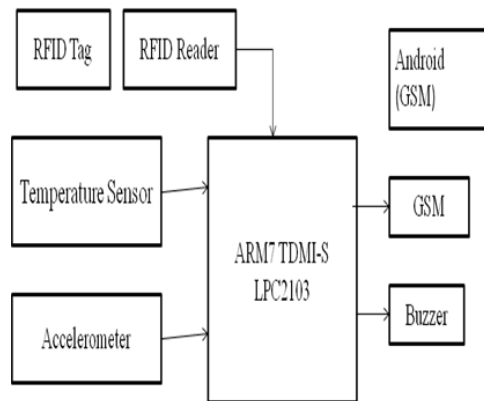

Figure 3: System Block Diagram of ARM7 Recognition

The triaxial accelerometer sensor is attached to the child leg, hand and back and has been used for capturing the acceleration of the movements associated. Sensors attached to the Leg and hand measures only x-axis or y-axis movements, where as sensor attached to the back measures both x-axis and y-axis movements.

Figure 4: Triaxial Accelerometer

RFID Module

Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. The technology requires some extent of cooperation of an RFID reader and an RFID tag as shown in figure 5.

Figure 5: RFID Tag Reader Top and Side View

An RFID tag is an object that is attached to table or bulky Items, when the child with RFID reader move towards a table or bulky material which can be harmful is identified and tracked using radio waves [6].

The tag reader is responsible for powering and communicating with a tag. The tag antenna captures energy and transfers the tag's ID. In our project we use near field communication using magnetic induction for transfer of power from reader to the tag.

Temperature Sensor and Buzzer

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. If the room temperature of the child goes beyond $40^{o}C$, then intimation will be sent through GSM for the parent's android mobile and Buzzer gets sounded for alert.

Microcontroller Board

The microcontroller used is LPC2103 ARM7 TDMI-S processor manufactured by Philips semiconductor technology. It monitors the child activity and sends messages or voice alerts to the parents mobile. It is programmed to process the input signals from accelerometer, temperature sensor and RFID sensor, these processed signals are sent to Android GSM mobile through GSM modem. The LPC2103 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation that combines the microcontroller with 32 kB of embedded high-speed flash memory. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical performance in interrupt service routines and DSP algorithms, this increases performance up to 30 pct over Thumb mode. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 pct with minimal performance penalty.

Due to their tiny size and low power consumption, the LPC2103 are ideal for applications where miniaturization is a key requirement. A blend of serial communications interfaces ranging from multiple UARTs, SPI to SSP and two I2C-buses, combined with on-chip SRAM of 8 kB, make the LPC2103 very well suited for communication gateways and protocol converters. The superior performance also makes the LPC2103 suitable for use as math coprocessors. Various 32-bit and 16-bit timers, an improved 10-bit ADC, PWM features through output match on all timers, and 32 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make the LPC2103 particularly suitable for industrial control and medical systems.

GSM Modem

This GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to send and receive SMS or make/receive voice calls. It can also be used in GPRS mode to connect to internet and do many applications for data logging and control. In GPRS mode you can also connect to any remote FTP server and upload files for data logging.

Figure 6: GSM Modem

EXPERIMENTAL RESULTS AND DISCUSSIONS

The performance of the feed forward neural network is evaluated with the ARM7 based microcontroller activity recognition. All the 6 activities of the child, recognized with neural network found to be efficient in terms of performance when compared to activity recognition using ARM7 based controller recognition as tabulated in table 2.

Table 2: Performance Comparison of Neural Network with ARM7 Recognition

S. No.	Activity	ARM7 Recognition Performance %	Neural Network Performance %
1	Standing Still	98	98
2	Walking	97	98
3	Toddling	96	98
4	Crawling	97	98
5	Rolling	98	98
6	Sitting Down	98	98

CONCLUSIONS

A neural network classifier has been designed for child activity recognition. Feed forward neural network is trained using trainbfg algorithm. The designed network performance is compared with the ARM7 based controller recognition whose mean performance is 98% respectively. The mean performance rate with neural network classifier is an improved one as compared to the previous results with ARM7 based recognition system.

It is being concluded that integrating activity recognition with neural network allows developing accurate and high performance systems.

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