FALL ACCIDENT DETECTION USING MICROSOFT KINECT

[1]KORNKRIT SIRIWONG, [2]RATTAKORN POONSUPH

[1,2]National Institute of Development Administration
E-mail: [1]s.kornkrit@outlook.com, [2]rattakorn@as.nida.ac.th

Abstract- This research aimed to study the motion of falling, slipping and stumbling that would lead to an accident, especially with a patient in a room at the hospital, which could result in the death of the patience. This study focused on the importance of an immediate help which is triggered by the motion sensing device called "Kinect" in the patient's room. This device consists of an infrared projector, an infrared camera, and a color detector. The price of Kinect device is considered affordable that's why it is wildly used as a motion sensor. The data collected by Kinect is then transformed into an algorithm which will be used to program accident detection. When the analyzed data shows that an accident has occurred, the system will immediately alert the rescuers or in this case the nurses on duty.

Index Terms-Kinect, Falling, Motion, Gesture, Posture.

I. INTRODUCTION

An accident is a physical incident that usually results in injuries or even death. The examples of an accident are road accidents, falling from a building, burns, poisoning, slipping,
stumbling, and falling. From the statistics taken from the studies of the accidents from slipping, stumbling, and falling (Slip, Trip, fall: STFs) in 2009 by the U.S Bureau of Labor Statistics, found that 25% of the accidents happened to 10,000 laborers were caused by falling, tripping, and slipping.

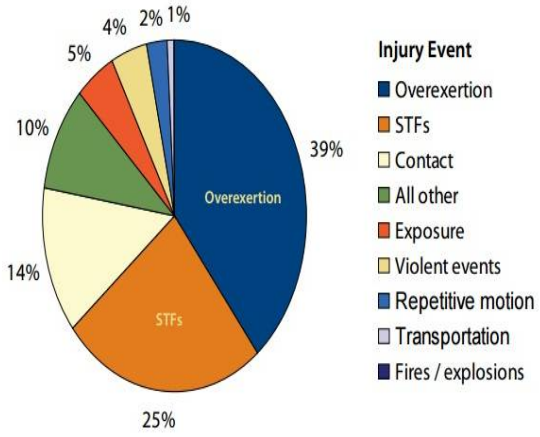


Fig. 1. Distribution percentage of hospital employee's accident separated by injury types [2].

Also, the data collected by the Department of Health, Social Services and Public Safety during the year 2004 –2009 [2] from the study of places and types of accidents shows that 41.4% of the accidents are domestic, as show in the Fig.2 below.

This information was then assessed with the data collected from 9,042 hospitals about cause of the death from domestic accidents and 36% of the death from accidents at home caused from falling, as shown in Fig 3.

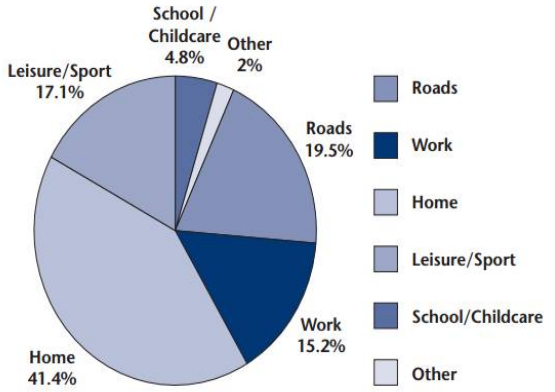


Fig. 2. A recent survey of 16 Accident and Emergency (A&E) departments in Northern Ireland [2].

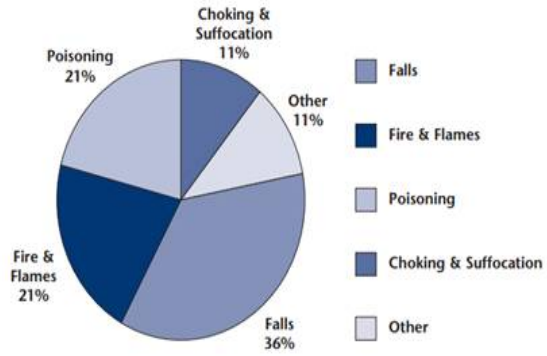


Fig 3. Cause of Death from Accidents in Home [2].

From the statistics shown above, studies were conducted further to find a way to prevent the loss. Up until the present time, many studies have been conducted to monitor the patterns of human movements. Chen Wu and Hamid Aghajan[3] studied this subject by using multiple cameras which were linked to the same network. They applied the framework of Opportunistic Fusion camera network which processed the data in 3D, including space, time, and attitude, based on the structure of human bones. This method, however, is unsuitable for this study as the process is too complicated. In addition, a lot of information needs to be gathered and the device is

expensive. Most researchers prefer collecting data in 3D. Gavrila and Davis [4] also explained human movements with 3D data by using MultiView digital camera. The result of this study is the Pose Recovery 3D. They also divided the characteristics of human motions by using an accelerometer which could give the most accurate results. However, this method, again, isn't practical when it is taken for using in daily as it is required the installment on a human body, making easily for an error to occur. The study of Cohen and Li [5] classified human movements by using the SVM technique from 3D visual-hull constructed on the silhouette suit. The program then analyzed the data and assessed it. Later, a copy of the assessed data was sent back to the original source.

Many researchers have tried different methods to analyze and assess the data. Corradini et al [6] has brought to light various methods to analyze and monitor human movements (e.g. stopping, turning to the left, turning to the right, waving to the left, waving to the right) by using Hybrid Neural Network. Zhao and Liu [7] used Centroid – Radii model to explain human movements in each frame. He applied "Nonlinear SVM Decision Tree Theory" to analyze human motions such as standing, sleeping, sitting down, walking, walking to the left, crouching, jumping uphill and jumping downhill. Wu et al [8] is another researcher who used an accelerometer to detect human movements via different sensors and various analytical algorithms such as Support Vector Machine (SVM), Frame-based Descriptor and Multi-class SVM (FDSVM), BPNN, Decision Tree (DT), and Navie Bayes (NV).While Kiran et al [9] compared the Supervised Learning to Unsupervised Learning algorithm, which includes K-means artificial neural network, self-organizing maps, and particle swarm optimization. They detected the movement of mountain climbing, jumping backwards, and pointing.

The results shown that Supervised Learning is more effective than Unsupervised Learning algorithm. In summary, algorithms and sensor devices play a key important role when it comes to collecting the most accurate data.

II. RESEARCH METHODOLOGY

Microsoft Kinect is a human-motion detector device and the data collected by its sensors is considered accurate. For this reasons, a lot of researchers have applied Microsoft Kinect into their studies. Raptistal is et al [10] used the real time action figure to classify the dance movements based on the movements of 16 main joints in a human body, in accordance with what is programmed in Microsoft Kinect. The result showed the accuracy percentage of 96.9% and only took 4 seconds to memorize the movements of bones. There are also a lot of studies that use Microsoft Kinect as a tool to detect the act of standing up, sitting down, and lying [11]. It is proved that was used BPNN method with the data collected by Microsoft Kinect, the outcome is the most accurate.

This study focused on the importance of the prevention of an accident which is caused by slipping, falling, and stumbling that occurs to patients or elderly in their room and find a way to prevent the injuries or even death. It's the study on human gesture recognition algorithm by using Kinect camera [12]. The researcher studied the movement of sitting, walking, and lying down by using Microsoft Kinect and 4 other theories.

TABLE I. Data from 4 theories [3].

	Actual / Prediction	Stand	Sit down	Lie down
Back Propagation Neural Network	Stand	1200	0	0
	Sit down	0	1200	0
	Lie down	0	0	1200
Support Vector Machine	Stand	1200	0	0
	Sit down	0	1200	0
	Lie down	0	0	1200
Decision Tree	Stand	1133	67	0
	Sit down	123	1077	0
	Lie down	0	55	145
Naïve Bayes	Stand	656	362	182
	Sit down	0	1094	106
	Lie down	0	0	1200

The comparing data in the table I table show that Back propagation neural network (BPNN) method gives the most accurate results. Therefore, this researchaims to sensors posture by Microsoft Kinect more than only stand, sit and fall. We have developed a posture pattern of Microsoft Kinect's sensor by adding a falling forward, falling sideways and falling backwards into this research to be a beneficial for the public.

III. PROCESSING AND ANALYZING

There are many factors that differ the data that a Microsoft Kinect camera can detect such as the angle of the camera, the distance between the camera and the patient, lights in the room, lights from outside, obstacles, the shape of the body, different standing and sitting postures, and also the pattern of the fall. This is why it is important to run several test with all the above factors to make sure that Microsoft Kinect camera will receive enough data which will be able to be used later in mathematical analysis.

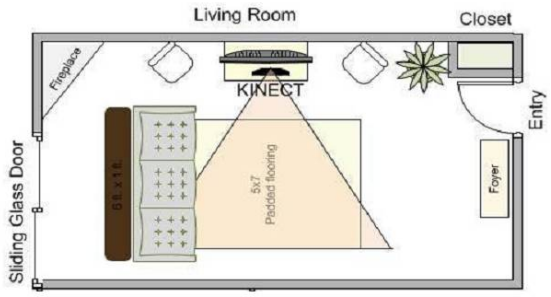


Fig 4. The model of a room with a Microsoft Kinect camera.

Other factors that can also change the test results are height and weight of the patients. Different heights and weights can result in different falling patterns, as shown in Fig. 5. [14,15]

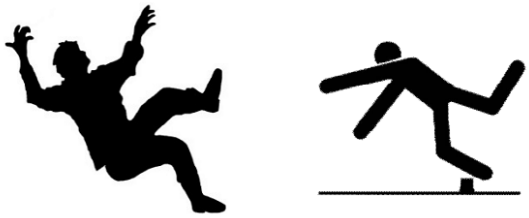


Fig 5. The examples of fall patterns caused from different height and weight of patients.

For this reason, a database of falling is created as a model of the study. When the data transmitted from Microsoft Kinect is analyzed and the algorithm is written. The system will send out the alarm to the rescuers. If it is approved that an accident has occurred, even with wide range of patterns of falling, tripping, and slipping, we can conclude that the system can effectively alarm the occurrence of an accident.

IV. THE EXPERIMENT

1. The researcher collected data from different styles and types of falling and set up a database by using Microsoft Kinect. The data was collected from a stunt who has 180 centimeters tall and 70 kilograms weighed. The stunt then performed different ways of falling as followed as shown in Fig.6.

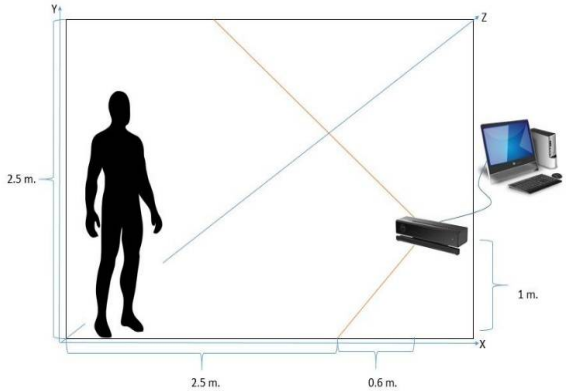


Fig.6 The experiment set up by using Microsoft Kinect.

Microsoft Kinect is installed in a room with no natural light except the fluorescent light. Also, the sensor is near the edge of a flat and stable surface, the position of the sensor is 1 meter from the floor, the detection of the sensor is between 0.6 meter and 3.1 meters and no other nearby objects is obstructing the field of view.
The first is falling forwards, which means falling towards the Kinect camera. The second is a side fall, meaning the line of the fall is aligned with the Microsoft Kinect camera. And then the third is falling backwards, which means the model stood facing Kinect camera and fell backwards.

2. The stunt then performed each gesture 10 times, 30 times in total and then performed with 10 other examiners; 4 male stunts and 6 female stunts with different heights and weights.
3. The researcher then analyzed the data and set up a database using Visual Gesture Builder program and wrote the Back propagation neural network algorithm by using Visual Studio 2013.

TABLE II. The experimental data from the results of 10 examiners in the experiment.

Stunt Gender	Height (cm.)	Weight (kg.)	#of Detected (Falling forward)	#of Detected (Falling Sideway)	#of Detected (Falling backward)
Male	172	83	10	10	10
Male	175	90	10	9	6
Male	180	53	7	7	9
Male	180	70	8	9	9
Female	150	42	9	9	10
Female	150	50	10	10	6
Female	152	48	9	7	6
Female	154	58	8	10	8
Female	158	58	7	7	5
Female	159	40	9	8	6
Total of the Microsoft Kinect detected the fall			87	86	75

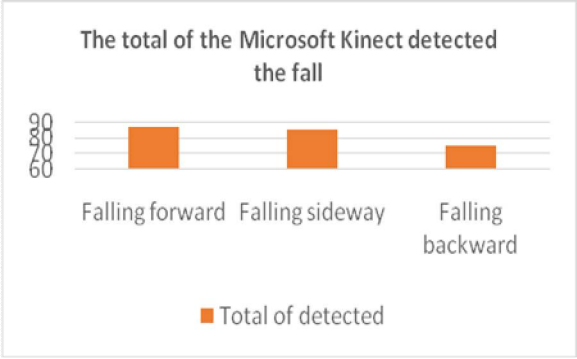


Fig 7. Demonstrates the total number of the fall. From 100 times of each gesture of falling performed by 10 examiners, Microsoft Kinect can detect 87 times of forward fall, 86 times of side fall and 75 times of backward fall.

V. SUMMARY

From the experiment, the differences of height and weight of the examiners hardly affect the experimental results. However, the factors that have an effect are the

installation of Microsoft Kinect, environment, obstacle and light reflection from windows. Essentially, gestures of falling used from database for comparison were the main factor that affected the result of the experiment. As such the gestures of falling of the examiners comparing with the master set of gestures in the database resulted in 87 times of forward fall, 86 times of side fall and 75 times of backward fall that were able to be detected by the program developed to be used with Microsoft Kinect. It spent lower than 0.2 sec. to process the calculation of the detection. It is noticed that the detected numbers of forward falls and side falls were more than the detected numbers of backward falls. Since the examiners can easily and naturally perform forward falls and side falls whereas the backward falls was more difficult. As a result of this, the number of backward falls was the least of detected gestures in the experiment.

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