A Study on Techniques of Person Following Robot

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ABSTRACT
Robotic industry has evolved so much and has been a revolutionary in helping human being to complete certain task. Without the help of industrial robotics to produce car, cellphone or a computer, productions will suffer as time is a very important factor for businesses. Researchers around the world understand this, and there is already an artificial intelligent robot being produced. Each year, there will be new findings to create a robot that may one day behave similarly like a human being. However, this paper will only discuss about person following robot, a robot that should help human in an environment such as hospitals, schools, or shopping malls.

General Terms
Person following robot

Keywords
Robots, Technique

1. INTRODUCTION
Having a robot assistant surely seems like a dream for most of us. A robot that can help us carry items, accompany us at shopping malls, or during a jogging session at the park. A robot that can help nurses at hospital, or bringing the medical supplies during war to injured soldiers. There are so many advantages of having such robot, that in the future, it will most likely be the trends. There are a lot of researches surrounding this topic. Person detection and tracking using diverse image features and classifications method [1], [2], [3]. Most of this research use a fixed camera, because when using a moving camera, there is a problem with background/foreground separation.

Laser range finders are commonly used for person detection and tracking for this type of robots [4], [5]. And also omnidirectional cameras [6], [7], being used but its limited resolutions are frequently not suitable for analyzing complex situations.Another popular method is using stereo in person detection and tracking. A method of tracking person by constantly using distance information received from a stationary stereo camera [8].

In this paper, five papers about techniques of person following robot were reviewed. This paper will only discuss in generic form of words, for better understanding among non-engineering readers. The result of this paper will include an easy to understand comparison, and should give readers brief knowledge about techniques available. The establishment of the framework for the implementation of ERP system in private institution of higher learning (PIHL) environment is a complex study. Based on the study conducted on the literature review and field studies, the researchers has found that the function of the role played by institutions of higher learning (IHL) is very broad and different from other organizations. Therefore, the suggested framework here is based on the hybrid framework which was developed by previous scholars (through books, case studies and published ERP research articles which are being reviewed for the implementation), the constraints mentioned for the IHL as a unique environment and our own case study on the ERP system implementation that has been developed base on the PIHL in Malaysia environment, research output on the perception and barriers for the ERP system implementation throughout the fifty (50) private universities in Malaysia. Furthermore, the framework also includes the first author provided firsthand information based on his experiences as a key member on ERP system implementation over a period of five (5) years. All the above information has been gathered which then being systematically unified in order to identify phases, critical success factors (CSF), deliverables and responsibilities. This framework has four stages, which comprise of project initiation, project execution, realization and operation and maintenance in which for each phase or stage will have a combination of CSF, deliverables and responsibilities.

This study will describe the validation result on the proposed framework. The validation study is to obtain feedback on the draft proposal of the framework and get the recommended improvements to rectify the weaknesses of the proposed framework. With the results of this study, researchers will examine whether the implementation of the framework is understandable, appropriate and accurate.

2. OVERVIEW OF PERSON FOLLOWING ROBOT STRUCTURE
A typical person following robot consists of several things. A body with wheels, laptop for processing information, and a detection device. Figure 1 and figure 2 shows a typical person following robot structure.

Fig 1: Example of person following robot

Fig 2: Example of person following robot handling juice to human.

3. CHALLENGES ON PERSON FOLLOWING ROBOT SCENARIO

There are several challenges that are being faced by researchers when building robots. For example, a person following robot should be functioning properly in a crowded environment. It should not be lost during tracking when there is a lot of movement in front.

Furthermore, person following robot designer should consider a place where there is uneven floor. A person following robot should also be able to increase its speed if the person is running. The robot should also avoid obstacles, be it static or moving obstacles. Sometimes, there will be a person who is much similar to the target person, and may be wearing similar clothes. The robot should be able to distinguish and follow the correct person. The space of the robot and the person followed should be in a safe distance. The robot should know when to stop, and avoid collision with the person.

4. RELATED WORKS

There are a few researchers that are focusing on person following robot implementation. For example research [9] that are concerned about cost. They built a robot with only one tracking device, which is a laser range finders (LRF). They use leg detection algorithm to detect a person to be followed. The algorithm processes the data given by LRF to detect target person's leg. The algorithm provides contrasting of which is the relative velocity of the target person with respect to the robot. The information will be passed to fuzzy controller which will set the speed needed by robot to follow the target person's leg. Fuzzy inference system is being used to deal with humanistic and complex situation where it is not possible with mathematical models. The fuzzy inference system that is being used in this robot is based on the one developed for car-following [10]. The testing showed that this robot is able to follow target person smoothly and safe distance. The robot can accelerate by inputs received from the movement of target person's leg. The safe distance is being set to 1m to avoid collision with the target person.

Research [11] use 2 stereo cameras to capture images. The images are then being analyzed using Lucas Kanade approach to remove disparity from the 2 images. It is using BSFS algorithm for detecting and matching feature points between the stereo images and between successive images of the video sequence. RANSAC (Random Sample Consensus) [12] is applied to the matched points to calculate the motion model of the static background. Stereo and motion information are fused in a novel manner in order to divide independently moving objects from the static background. BSFS algorithm they have created is good because the differences of the features on the target person will not change too drastic between successive frames.

The entire techniques uses only gray-level information and not attempting to create a geometric model of the environment, thus it means the target person should not necessarily wear different cloth color from the background. It is robust even though when there are moving objects in the scene. Using BSFS, the other advantage is the stereo system does not need to be measured internally or externally. Face detection algorithm also included to increase robustness, even though target person does not necessarily facing the robot.

Authors in research [13] built a robot which uses moving stereo camera that should be tracking persons using depth templates. Depth template is a template for human upper body. For this system, they use 3 templates with different direction of body (left, front, right). The templates are being made from the depth images where target person is 2 m away from the camera. Depth template is a binary template, the background and foreground value are adjusted according to status of tracks and input data. For tracking a person, EKF (extended kalman filter) tracker is being used in providing predicted scene positions. It will continuously check if new person appears in the image. To remove false detection from objects with similar attributes to target person, SVM (support vector machine)-based person verifier is being used with intensity images. Combining depth template approach with EKF and SVM based verifier, a robust person following robot has been created. This algorithm however does not consider the case where multiple persons are too close to be divided by depth information. To eliminate this problem, it would be wise to include other visual information such as color and texture in the future. It is also necessary to create an upgraded version where the robot can avoid static obstacles and plan an effective route in a more complex environment.

A research by [14] is an upgraded version of robot from this research [13]. This robot is created by the same person, J.Satake and J.Miura. The basic of the robot are the same, with usage of depth templates, EKF, and SVM based verifier. The problem of previous robot, obstacles avoidance has being covered by laser range finder (LRF). Color information is being included, however when the robot is in low light environment, the robot can't differentiate 2 or more target person with cloth in similar colors. To overcome this new situation, SIFT is being introduced. SIFT (scale invariant feature transform) is a powerful image feature that is constant to scale and rotation in the image plane and also robust to lighting condition. Mistaken corresponding points from SIFT is being filtered using RANSAC (Random Sample Consensus). SIFT features appears to decrease when the distance from the camera to target person increases. To overcome this problem, distance dependent threshold is being used to cope with decreases number of SIFT features. In the future, to add robustness, personal features such as height or gait patterns should be included.

A research done by [15] is probably the most basic system among 4 other robot systems. However, the intended result

Table 1: Comparative techniques of person following robot

Author	Device for detection and tracking	Unique Features	What is being detected on the target person
S.Shaker, J.J. Saade, D. Asmar (2008) [9]	Laser range finder	Fuzzy inference system, leg detection algorithm	Target person's leg
Z.Chen, S.T.Birchfield (2007) [11]	2 stereo cameras	Lucas Kanade approach, BSFS algorithm, RANSAC, face detection algorithm	Disparity and feature points between 2 images by 2 stereo cameras
J. Satake, J.Miura (2009) [13]	Stereo camera and EKF tracker	SVM based verifier	Human upper body in depth images
J.Satake, M. Chiba, J.Miura (2012) [14]	Stereo camera, EKF tracker, and laser range finder	SVM based verifier, color information, SIFT features, RANSAC	Human upper body in depth images, SIFT features to differentiate 2 persons with similar clothing.
B.Ilias, S.A. Abdul Shukor, S. Yaacob, A.H.Adom and M.H Razali (2014) [15]	Kinect high speed sensor	Processing.org software, human skeleton method	Human skeleton method. Target person need to raise hands.

has been received. The system is using Kinect high speed sensor to detect and tracking movement or target person. The target person needs to raise their hands in front of the robot in order for it to calculate using human skeleton method. The input then passed to Processing.Org software. It then being passed to BASIC stamp for Kinect. After that, it being passed BASIC stamp for ultrasonic, and lastly to BASIC stamp for MOTOR to generate movement of the robot. They found out an issue with using Kinect sensor which is unavailability to operate outdoors due to ultraviolet rays. They overcome this issue with 4 layers of 5% tinted film at the IR depth sensor to block the ultraviolet rays. The qualities of images outdoors have been improved significantly. Table 1 compares the techniques of person following robot from previous researchers.

5. SUMMARY

From the techniques reviewed, there are several ways to design a person following robot. This paper does not intend to mention which is the best solution. Each has its own merits. Out there, there may be a lot more solutions provided for person following robot.

However, one technique that stands out would be the [14] system. It has grown from [13] to be quite a complete system. It can avoid obstacles, distinguish between 2 similar persons, and robust enough to use in crowded environment. It will cost higher compared to others because of the number of devices and processes being used.

The simple solution such as [9] and [15] each completed its targeted task. It will cost lower than [13] and [14]. However, there is a concern whether it can operate in a complex environment such as experiments in [13] and [14] provided.

System [11] has its own advantages as it may cost slightly lower than [13] and [14] because of the low number of devices. BSFS algorithm being presented also is a powerful tool and robust enough to handle moving objects in the scene. However, in the future, it would be nice to see this system being experimented in complex environment such as [13] and [14]. In the future, the usage of robot in helping human's task would be massive. It will be normal one day to find out person following robot has taken over simple task, such as being a driver, maid, gardener, or even security guard. It is necessary for human being to explore the robotic knowledge as it knows no boundaries. This paper describes review of person following robot recent research. Along the way, each system's advantages have been identified. This paper begins with brief scenario of person following robot and ends with analysis and discussion.

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