The Development of Tracking System Technology for Underground Miner

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***Abstract*—This paper will discuss about the development of tracking system technology that use for object management at any given time. An object tracking technology has been widely used for certain purposes. This is because the aim presence of an object tracking technology, to help people in various activities. For the example is like for reasons of security, management, mapping objects, and more. Tracking system technology also has many methodologies, frameworks, and models that have been developed. Technical tools used also vary, conformed to the existing development research. In this paper, object tracking to be discussed is a human. It is correlated with so many activities that are useful in tracking important events, in the life cycle of human important activities.**

***Index Terms*—Tracking system technology, object, methodologies, framework, models, technical tools, human, activity, Miner.**

I. Introduction

Tracking system technology developments increasingly varied and interesting to be have researched. This is because the use of these technologies for a wide range of important activities undertaken by humans. Especially in activity that have to be done, to fulfillment of human rights and obligations. The use of tracking system technology is like for reasons of security, management, mapping objects, and more. In this paper, object tracking to be discussed is a human. It is correlated with so many activities that are useful in tracking important events, in the life cycle of human important activities. The example of activity that use a tracking system technology for human use such as, people tracking on public space (pedestrian tracking at the garden, visitors tracking at the mall, visitors tracking at the museum, visitors tracking at the station, all of this activity correlated to the security issues).

People tracking activity for mapping object (human) management also have to be done in an important human activity such as when the peoples doing a mining at underground site, to perform mining worker. Tracking system technology can be used to do management of miner member, to count and aware about the miner position when they perform mining. This is an important activity because when they perform mining, the potential problem such as separate from their group, go to the wrong place, and not detected by their miner group, can be happen when perform mining. Tracking system technology can decrease are problem like that, because when we developed that technology, all of the position object (human, miner) can be detected.

Tracking system technology also has many methodologies, frameworks, and models that have been developed. Some of that is multi-mode dead reckoning system for pedestrian tracking using smartphone [1], multi sensor information fusion for people tracking with a mobile robot: a particle filtering approach [2], multi-person tracking with a network of ultra-wideband radar sensors based on gaussian mixture PHD filters [3], An adaptive motion model for person tracking with instantaneous head-pose features [4], directional people counter based on head tracking [5], and many more. In the next section, we will briefly explain tracking system technology methodologies, frameworks, and models that have been developed conformed to the existing research.

II. Study Of Literatures

In reviewing the development of tracking system technology as the focus topic of discussion, which is use in the life cycle of human important activities, there are many methodologies, frameworks, and models that have been developed. The authors make description and investigation of the problem based on the literatures as follows.

Multi-mode dead reckoning system for pedestrian tracking using smartphone, presents a tracking system that implemented on a commercial off-the-shelf smartphone equipped with a built-in inertial measurement unit with 3-D accelerometer and gyroscope. It achieves real-time tracking and localization performance with an average position accuracy of 98.91% [1].

Multi-sensor information fusion framework is presented for fusing the laser range finder (LRF) data and the monocular camera data. Based on this framework, an LRF-based detection algorithm is proposed to identify the pairs of human legs, by combining motion information and metric features [2].

Multi-person tracking with a network of ultra-wideband radar sensors is investigated the use of Gaussian mixture probability hypothesis density filters for multiple person tracking using ultra-wideband (UWB) radar sensors in an indoor environment [3].

Adaptive motion model for person tracking with instantaneous head-pose features presents behavior based tracking of people in low-resolution using instantaneous priors mediated by head-pose. Extend kalman filter to combine motion information with an instantaneous prior belief about where the person will go based on where they are currently looking [4].

Directional people counter based on head tracking presents an application for counting people through a single fixed camera, when people moving through the supervised area. Different tests using a set of real video sequences taken from different indoor areas give results ranging between 87% and 98% accuracies depending on the volume of flow of people crossing the counting zone [5].

Person tracking in large public spaces using 3D range sensors is a method for tracking the position, orientation, and height of persons in large public environments. This method performs very well and is more robust to occlusions than a laser range finder-based tracker [6].

Online multi-person tracking-by-detection from a single, un-calibrated camera is approach for multi-person tracking-by detection in a particle filtering framework. The method achieves good performance on a large variety of application scenarios, outperforming other state-of-the-art algorithms, some of which rely on scene-specific information, multiple calibrated cameras, or global optimization [7].

Scalable semi-automatic annotation for multi-camera person tracking is methodology for evaluating multi-camera people-trackers on large video data sets, found 99% of the automatically annotated frames to be correct [8].

Real-time tracking of moving persons by exploiting spatio-temporal image slices addresses the problem of analyzing human motion in an image sequence [9].

Design of wireless sensor networks for pilgrims tracking and monitoring is method that propose about pilgrims that will have the RFID tag. The transmitting section consists of RFID reader, microcontroller and zigbee transceiver. Every pilgrim will have a unique ID [10].

People tracking and location based services via integrated mobile and RFID technology, explores the solution to track the movement of pilgrims via RFID technology by make integration of different mobile technologies for crowd management [11].

Pilgrim tracking and identification using the mobile phone, method consist of software that can be downloaded to the mobile phone of every pilgrim upon arrival to the Kingdome of Saudi Arabia, then RFID tag can be programmed and be placed in inside the mobile [12].

Pilgrims tracking using wireless sensor network describes a prototype of a wireless sensor network developed for tracking pilgrims. The system consists of mobile units carried by pilgrims and a wireless sensor network fixed in the region. The WSN communicates to a server, the location information of the pilgrims periodically based on pre-set parameters [13].

Person tracking using kalman filter in wireless sensor network is a module in the person detection and tracking project. The movement of the person is detected by the PIR sensor and the position of the person is obtained using RFID reader. Kalman filter predicts the next position of the person [14].

An RFID-based pilgrim identification system use a wristband RFID tags to tracking pilgrimage. A pilot study is performed on 1000 pilgrims from Ivory Coast to prove the concept and get feedback on the performance [15].

Data fusion for person identification in people tracking presents four different approaches for identifying persons during tracking. First technique uses color information extracted from camera images to distinguish between persons. The second technique uses reflectance intensities, which can directly be provided by the laser range sensors for this purpose. The third method is again based on camera information, but it employs a probabilistic shape and motion model for each person it tracks. Finally, present an approach that uses a network of dedicated sensors, which directly transmit identification information for each person [16].

Wireless sensor network for tracking pilgrims and their medical parameters is interfaced to the internet through gateway available from an internet service provider. Each pilgrim is given a mobile sensor unit which includes a GPS chip, a microcontroller, and antennas [17].

RFID-based system for pilgrim management is propose a system to manage pilgrims in KAIA by using the RFID technology. Each pilgrim is given an ID card with a unique number. This card used to identify the pilgrim in different stages of the arrival process. The proposed system helps pilgrims finding their ways to the designated waiting area for their nationalities and helps officials registering pilgrims, editing their information, and searching for them [18].

Soft-biometrics dataset for person tracking and re-identification, present a new dataset for the tasks person detection, tracking, re-identification, and soft-biometric attribute detection in surveillance data. Person tracks are labeled with consistent IDs, as well as soft-biometric attributes, such as a description of the clothing, gender, or their height [19].

Activity recognition using visual tracking and RFID presented a computer vision system that features a combination of robust real-time visual motion tracking with custom RFID tracking technology in order to reliably analyze human object interactions. It was shown that the two modalities complement each other very well [20].

Crowd management with RFID & wireless technologies provides a management framework for large & dense crowds. The analysis of the technological framework is done with help of Hajj & Kumbh case studies. RFID technology would ideally carry some PDA [21].

Hierarchical approach to weight equations in face tracking and recognition framework is the proposed method that combining the discrimination rules with the hierarchical approach, that can remarkably improved the discrimination performance for 100-person face tracking and recognition [22].

Cooperative hybrid multi-camera tracking for people surveillance is a hybrid visual tracking system for event detection and people tracking. This surveillance system is composed of a stationary camera and a pan/tilt/zoom (PTZ) camera. The stationary camera has a wide field of view and is attentive to the scene for event detection. The PTZ camera is activated if an event is detected by the stationary camera. It then pans and tilts to center the target in its view and zooms in to obtain identifying details of the target that may not be clear to the stationary camera [23].

Detection methods improving reliability of automatic human tracking system is propose the ripple detection method and the stationary net detection method. These are examined using a image processing simulator, because an individual can not be accurately identified in the current image processing [24].

Fast and robust algorithm of tracking multiple moving objects for intelligent video surveillance systems is an intelligent image processing method for the video surveillance systems. This technology detecting and tracking multiple moving objects, which can be applied to consumer electronics such as home and business surveillance systems [25].

Multi-camera multi-person tracking for easy-living is a practical person-tracking system that uses two sets of color stereo cameras for tracking multiple people. The stereo images are used for locating people, and the color images are used for maintaining their identities. The system tracks multiple people standing, walking, sitting, entering and leaving the space also [26].

Multiple cameras using real time object tracking for surveillance and security system is approach for multi-camera object detection and tracking in video. The algorithm is tested for different video data set. The detected object is represented by its centroid and the rectangular shape around the object boundary. This would be helpful in surveillance systems [27].

Short range tracking of moving persons by UWB radar system sensor network proposed an approach for tracking moving person. The result is decreasing error probability of target detection for multiple moving target scenarios [28].

Person identification by integrating wearable sensors and tracking results from environmental sensors is a method of integrating laser range finders (LRF) in the environment and wearable inertial sensors. Time sequences of angular velocities estimated from both LRF and wearable sensors are matched to identify people [29].

Pedestrian tracking with shoe-mounted inertial sensors is navigation system that tracks the location of a person on foot is useful for finding and rescuing firefighters or other emergency first responders [30].

RFID technology and crowded event management proposed a wireless smart wrist strap RFID system combine with ATMEGA 128L sensors to develop [31].

Efficient wireless sensor network rings overlay for crowd management is proposed an optimal monitoring and evacuation model for pilgrims in Arafat area of Makkah, with the aid of wireless sensor and actuator networks (WSAN). The integration with RFID technology is proposed to facilitate the staged evacuation of the crowd. The performance of the proposed model is evaluated using simulation experiments [32].

Person re-identification visualization tool for object tracking across non-overlapping cameras is proposed a visualization tool system for person re-identification when tracking objects across non-overlapping cameras. The accuracy of person re-identification can be increased using the generated database because the amount of training data is increased [33].

Based on the study of the development of human tracking system technology that became the topic of discussion, the description and investigation of the problem with reference to the literature study, raised an interesting question for further discussion, namely:

- Are there similarities, differences, things that can be criticized, as well as being integrated into a new idea (open research problem) based on the literature studies that have been done?
- Which methodologies, frameworks, and models that makes a significant contribution for the optimization of human tracking system technology?

The answers of the questions, the author examined further in next section.

III. RESULTS AND EVALUATION

According to the study of literatures in previous section (section two), we can make a agglutination of the methodologies, frameworks, models that have been developed conformed to the existing research, that have been used to optimization a human tracking system technology. The agglutination is divided into a several point.

A. Ultrawideband Radar Sensor.

We found similarity technique in use of method for multi-person tracking with UWB radar sensors based on Gaussian mixture PHD filters [3] with Short range tracking moving persons by UWB sensor network [28]. According to this result, we can found that UWB sensor can be good implemented for tracking a moving multi-person in short range indoor environment.

B. Laser Range Finder.

Fusing the laser range finder with the monocular camera data, can get the flexible robust tracking result and high tracking accuracy [2]. This result is similar when we proposed method to integrating laser range finder with the wearable inertial sensors [29] that get a precisely tracking result. The unique things that we get, when do a person tracking with 3-D range sensor [6] that can achieved a better result than laser range finder. It means, when we want to get a precise result, we applied 3-D range sensor to tracking person in public space.

C. Kalman Filter.

Extend kalman filter to adaptively combine with instantaneous prior in tracking [4] can give us a good result in tracking such as we get a clear image validation that showed intentional of human head pose tracker. The contradictive result we get when we use kalman filter combine with wireless sensor network [14]. The results give us a clear notify localization error of tracking person, not pointing to the human, but to their error tracking location.

D. Enhanced Tracking With Use Of Camera.

The use of camera technology for tracking person has been used in several researched. Such as by un-calibrated camera [7], multi camera person tracking with scalable semi-automatic annotation [8], camera with data fusion [16], cooperative hybrid multi camera tracking [23], multi camera for easy living [26], multi-camera using real time object tracking [27], non-overlapping camera with re-identification visualization tools [33]. Results from un-calibrated camera [7], doesn't give a clear parameter and validation of tracking. Multi camera person tracking with scalable semi-automatic annotation [8], give 80% tracking accuracy all of video frames are automatically annotated on 60cm tracking environment. Camera with data fusion [16] gives us four different approached to distinguish between object while tracking multiple moving object (human). It means we cannot have a specific result of tracking, only have a method to distinguish the object (human). Cooperative hybrid multi camera tracking [23] obtain identifying details of the target that may not be clear to the stationary camera. It means we enhanced a stationary camera ability to tracking a person that used for surveillance. Multi camera for easy leaving [26] only give locating people result and their identities. Multi-camera using real time object tracking [27] also extend the use of stationary camera with four different approach, to give a comparison with the surveillance tracking result and detect the moving

object in real time video sequences and live video streaming. Non overlapping camera [33] increased accuracy of person re-identification using the generated database because the amount of training data is increased. The tracking technology with camera, commonly uses for a surveillances and securities issues. This model also good for tracking a person in a short range area like a home, garden, etc.

E. Radio Frequenzy Identification (RFID).

The use of RFID technology, into one of the ways that are widely used for tracking a human. Wireless sensor network (WSN) with RFID [10] can give a clear tracking result and health parameter on the pilgrim member. This similar with [13], combine WSN with RFID by mobile phone, the result can track specific pilgrims (tested successfully in pilgrim session). WSN with RFID [32] also use for tracking pilgrim for evacuation use and give a efficient results. Integrated mobile phone with RFID [11] can enhance the accuracy and tracking of pilgrims, but pilgrims must bring a mobile phone. We found the similarity in [12], the pilgrims must bring mobile phone where RFID tag placed in it, and download software for the tracking activity. Also with [21], the PDA (right know we call smartphone) integrated with RFID but doesn't give a clear results of tested tracking. Wristband RFID tag [15] successfully tested in 1000 pilgrim member from Ivory Coast when they do Hajj to tracking them. The problem founded that is pilgrim members didn't want restore wristband RFID tag. ID-Card with RFID [18], helps pilgrims finding their ways to the designated waiting area for their nationalities and helps officials registering pilgrims, editing their information, and searching for them. The deficiency of this method is the activity of tracking can be used in King Abdul Aziz International Airport only. Visual tracking with RFID [20], give accurate estimation of high level interactions between people and objects for application domains such as retail, home-care, workplace safety, manufacturing and others. The use of RFID technology commonly uses for tracking a pilgrim in Hajj activity, it means RFID can do a well multi-person tracking in indoor and outdoor area environment.

F. Other Models and Technology.

Mobile phone with 3D accelerometer and gyroscope [1], can give average position accuracy of pedestrian until 98,91%. Head tracking with video sequence [5], the test from different indoor areas give results ranging between 87% and 98% accuracies depending on the volume of flow of people crossing the counting zone, it means, if people increase, the accuracy result of tracking can decrease and vice versa. Spatio-temporal image slices [9] give us a clear result for tracking person but only use for indoor to surveillance issue. WSN with mobile sensor unit includes GPS chip [17], success to track a specific or group of pilgrim. Soft-Biometrics Dataset for Person Tracking and Re-Identification [19], good use in indoor area to tracking a person for security issue. Hierarchical Approach to Weight Equations in Face Tracking and Recognition Framework [22], success to tracking but only ten person in indoor environment. Ripple detection method and the Stationary net detection method [24], these methods can be efficient to detect a target if the search cycle is near the walking speed. Fast and robust algorithm [25], good implemented for video surveillance system like in home. Shoe-mounted inertial sensors [30], tested in outdoor and indoor environment and good track person only.

According to the agglutination, we can make a taxonomy table /map of researched tracking system technology to give us a clear parameter of a open research problem from tracking system technology.

Model / Ref.	A	B	C	D	E	F
[1]						■
[2]		■				
[3]	■					
[4]			■			
[5]						■
[6]		■				
[7]				■		
[8]				■		
[9]						■
[10]					■	
[11]					■	
[12]					■	
[13]					■	
[14]		■				
[15]					■	
[16]				■		
[17]						■
[18]					■	
Model / Ref.	**A**	**B**	**C**	**D**	**E**	**F**
[19]						■
[20]					■	
[21]					■	
[22]						■
[23]				■		
[24]						■
[25]						■
[26]				■		
[27]				■		
[28]	■					

Model / Ref.	A	B	C	D	E	F
[29]		■				
[30]						■
[31]					■	
[32]					■	
[33]				■		

Table 1. Taxonomy of Literature

Note:
Model: The Agglutination of model.
Ref. : Reference from literature.
A : Ultrawideband Radar Sensor.
B : Laser Range Finder.
C : Kalman Filter.
D : Enhanced Tracking With Use of Camera.
E : Radio Frequency Identification (RFID).
F : Other Models and Technology.

IV. CONCLUSION

At this section, will explain the conclusions of the study, the development of tracking system technology based on the results and evaluation on section three, so that it can answer the question in section two, which the methodologies, frameworks, and models that makes a significant contribution for the optimization of human tracking system technology and things that can be a new idea for the open research problem. The conclusion is divided into a several point.

a. Tracking a moving multi-person in short range indoor environment can get a good result with ultrawideband radar sensor technology.
b. If we want to get a precise result, we applied 3-D range sensor to tracking person in indoor short public space like mall, museum, etc.
c. Kalman filter results give us a clear notify localization error of tracking person, not pointing to the human, but to their error tracking location.
d. Enhanced tracking with camera good for tracking a person in a short range area like a home, garden, etc.
e. The use of RFID technology commonly uses for tracking a multi person (pilgrim) in Hajj activity. It means with the RFID technology, can do a good multi-person tracking in indoor and outdoor environment.

From this conclusion, now we know that tracking a person in short range environment can have a good result with ultrawideband radar sensor, 3D range sensor, kalman filter, and with enhanced camera technology. If we want a tracking multi person in indoor and outdoor environment, we can enhance the radio frequency identification (RFID) technology, it can be good to tracking a member of miner when perform mining activity. The open research problem is make a precise comparison of an enhanced RFID technology (like the [34] [35] do), which RFID tools and model that can give us a precision, accurate, and stable result for a tracking multi person in indoor and outdoor environment, especially to track a miner members when they perform mining.

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