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Tracking passenger movement with ground-based laser scanner

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Abstract:
It is important to count the number of passengers or to measure a trajectory of passengers in many fields, such as security of a building, marketing, etc. Various studies are conducted on the methods of counting or tracking passengers.
For example, cameras have been mainly used in existing studies, but the disadvantage of using cameras is that geometric parameters like distance and velocity can't be directly measured. Radar sensors are also used. They can measure distance and velocity, but their viewing angle and angular resolution is very limited.
Hence, in this study, among those methods mentioned above, we used laser scanners, whose viewing angle is wide and the angular resolution is high. The goal of our study is to track passengers by laser scanners and evaluate the possibility quantitatively, and as the first step of tracking passengers, we attempted to detect passengers from scanner image data. We developed an algorithm for passenger detection and demonstrated the validity of the algorithm through an experiment.

1.Introduction

It is important to count the number of passengers or to measure a trajectory of passengers in many fields, such as security of a building, marketing, etc. However, at the present, that is done through visual interpretation of the image data. Hence, now the demands for automatic counting and tracking of passengers are increasing, so various studies for automation are conducted for example using cameras, radar sensors, and so on.

In this study, among those sensors we use laser scanners, and evaluate the possibility quantitatively,. The goal of this paper is to detect passengers as the first step of tracking passengers.

2.Comparison of sensors

In the past studies, cameras have been mainly used. The disadvantage of using cameras is that geometric parameters like distance and velocity can't be directly measured. Stereo vision overcomes this problem partly, but it doesn't do perfectly.
Moreover, passengers can't necessarily be counted exactly in case they cross with each other. In order to avoid it, the position and the angle of cameras are limited, and their viewing range also becomes so narrow.

Another sensor can measure geometric parameters directly. Radar sensors are the first ones of this category. By emitting modulated pulsed HF-radiation, the relative radial position and velocity of objects is detected using the time-of-flight principle and the Doppler effect. But the disadvantage of radar sensors used today is their limited angle of view due to a fixed antenna. Moreover, their angle resolution is too poor to track passengers. A typical sensor has an angle of view of 12 degrees and an angular resolution worse than 4 degrees.

Laser scanners can also measure the geometric parameters directly by using the time-of-flight principle. Due to the very small divergence of the emitted laser pulse, the angle resolution is much higher. Latest sensors operate at distances up to 100m with an angular resolution of 0.25 degree and a measurement accuracy of typically +/- 5cm. Moreover, the angle of view of this scanning system is much wider, 270 degrees. Thus, wide range can be measured by scanning horizontally near the floor.

3.Experiment

We made an experiment of tracking passengers. We tracked passengers near an exit of an exhibition hall by using two laser scanners, which are IBEO's two-dimensional LD A. The reason of using two sensors is to make one

support the other in case of the object hidden from the view of one sensor.
The scanning frequency of laser scanners is about 10Hz (about 10 scan data are obtained every second), and 1440 points are scanned at one scan. Moreover, we also used video cameras to compare with scanned data.
Fig.1 shows the sketch of the experiment.

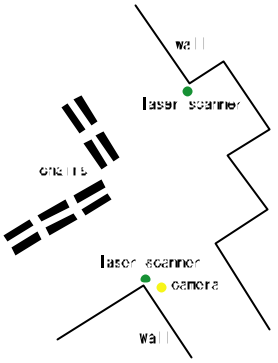


Fig.1. The sketch of the experiment

4.Passenger Detection

4.1 Preparation

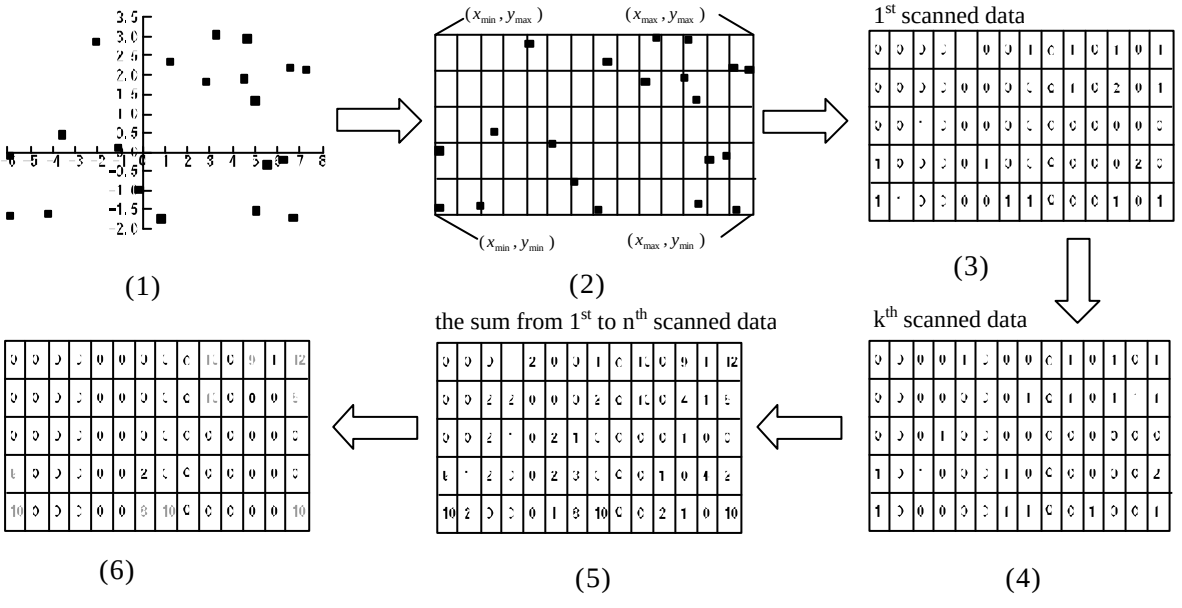
The obtained data are polar coordinate data, whose origin is the position of each laser scanner. Thus, we converted them to Cartesian coordinate data. Then, by linear transformation, the coordinate system of one scanned data were transformed to that of the other, and coordinate data in a single coordinate system were obtained. Moreover, since there was the gap between two data, we synchronized two data.

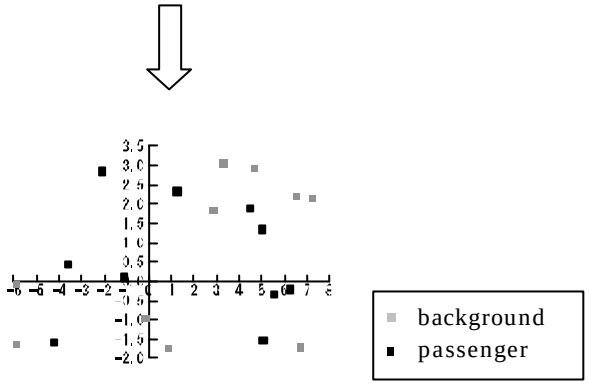
4.2 Algorithm for passenger detection

By using obtained coordinate data, we detect passengers. In order to do it, we must separate passengers from scanned image.
An algorithmfor separating is as follows:

(1) Coordinate data to tracking points
(2) Divide into grids
(3) Count the dots within each grid
(4) Repeat (1) to (3) for all scanned data
(5) Sum up the dots of all scanned data in each grid
(6) If the sum is smaller than a certain value (we define border value), the value of the grid is changed to 0
(7) The dots in the grid with nonzero value ——— background
The dots in the grid with 0 ——— passengers

Fig.2 illustrates this algorism.





(7)

Fig. 2. Algorithm for passenger detection

4.3 Results

By using the algorism mentioned above, we detected passengers. Since passenger detection was influenced by two parameters of border value and grid size, we changed these values, and obtained another values that could detect better.
The result of detecting passengers is shown in Fig.3.

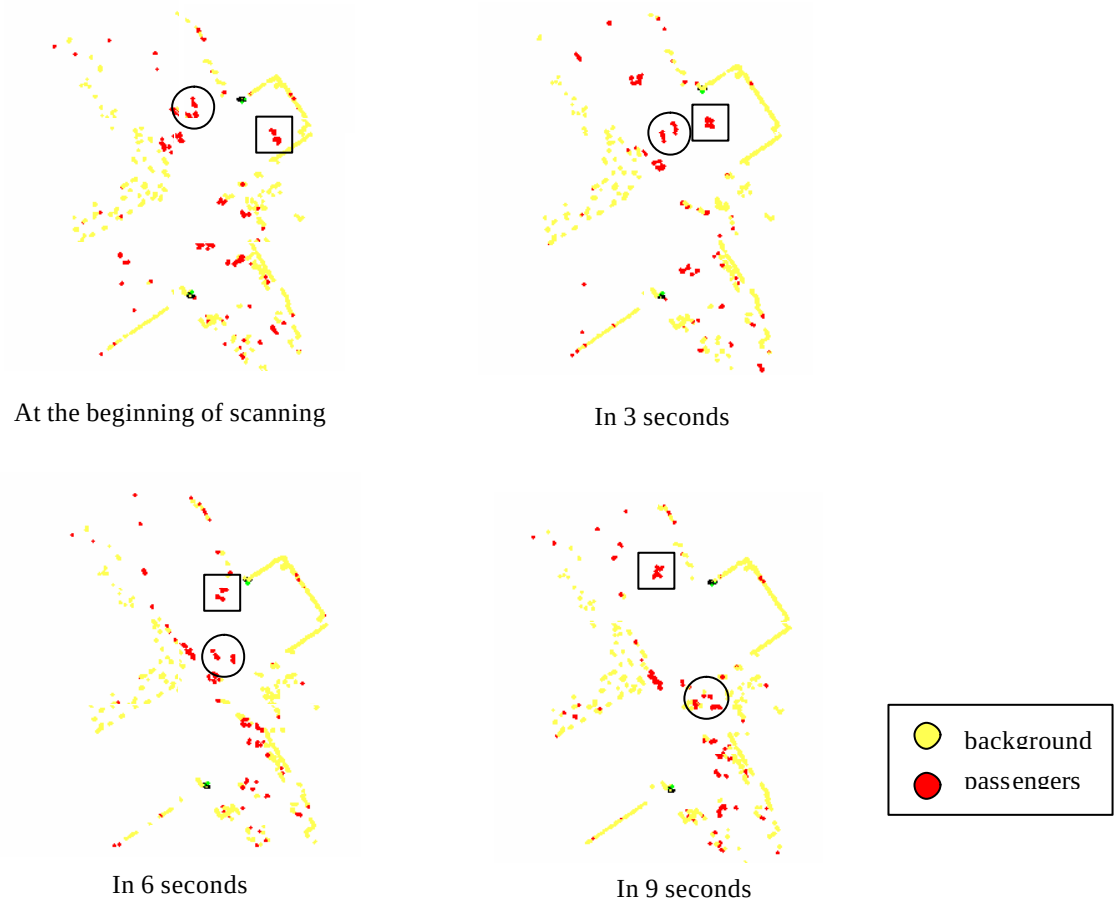


Fig.3. Result of passenger detection

In Fig.3, black dots denote passengers, and gray dots represent background. The squares or circles show a certain passenger. This figure shows that despite a little detection error, passengers can be detected by the method mentioned above, but some passengers who don't move a lot can't be detected.

5.Summary and Future Research

This paper proposed a method for passenger detection. Through an experiment, it is demonstrated that passengers can be detected though it doesn't perfectly separate passengers from images, for example, in case passengers don't move a lot, we don't always succeed in passenger detection.
In addition, that is the first step of tracking passengers. Thus, we will develop methods for tracking. Moreover, we will compare the tracking result with camera's image data, which were also used at the experiment, and explore the possibilities of those methods.

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