INDOOR ORIENTATION AND MAPPING

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Abstract

The paper deals with utilization of the laser rangefinder for navigation and mapping of unknown indoor environment. Navigation algorithm is based on two pictures comparison of unknown space and gain of the correlation function maximum. The position change (Δx, Δy) of the rangefinder is calculated as a maximum of correlation function. The goal is to improve the accuracy of odometric and inertial methods for localization and navigation of robot system in indoor environment.

1 Introduction

The robot movement regulation in this environment is one of the important activities. From the point of navigation, the tasks of robot movement regulation, localization of the robot position and environmental mapping, are fundamental. The mutual interaction between the tasks is determined by the ro[1]bot target (Figure 1).

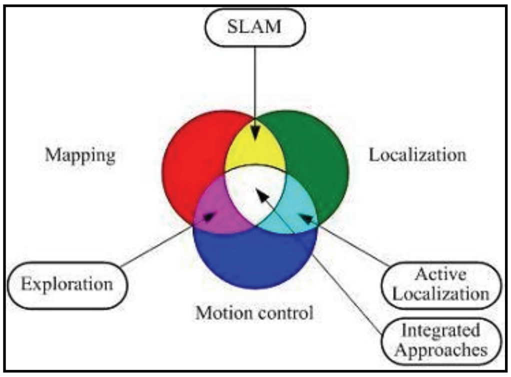

Figure 1: Interaction between the tasks

The robot position measurement and its interaction with obstacles, potentially scanning of robot environment is the precondition for the creation of environmental map. The aim of SLAM (Simultaneous Localization and Mapping) is the creation of 2D orthogonally environment map. The criterions of the mapping quality evaluation can be: accuracy, credibility, feedback of verification, creation of a map with the least number of measurement steps. For the indoor applications, odometric or inertial methods for measurement of absolute or relative robot position are used. However, both of them do not show long – lasting accuracy, they are encumbered mostly by accumulative faults as a result of measurement. From long – lasting point of view, they depreciate the measurement. Consequently, localization systems based on inertial and odometric methods are not appropriate for the map creation of indoor environment. This article deals with the option how to increase the measurement accuracy of the global and local robot position.

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2 Utilization of new methods

In the case of using algorithm for navigation and position correction based on measured dates from the laser rangefinder, there is assumption of accuracy increasing of position localization. The basic idea of the algorithm is the condition that with small change of rangefinder position the correlation among measured dates will be sufficient for exact definition of their coordinates change. Date correlation will be carried out between measurements in time t0 and subsequent time t+n.

Equation of correlation:

$$K(\Delta_X, \Delta_Y) = \sum_j \sum_i f[(x_i + \Delta_i), (y_j + \Delta_j)] f(x_i, y_j) \quad (1)$$

Where: Δ_X, Δ_Y the position change description of the measurement system coordinates

$f(x_i, y_j)$ is the point position

The navigation algorithm looks for maximum correlation value. In the maximum of this function, values Δ_x and Δ_y describe the position of the measurement system coordinates as shown on figures 2 .

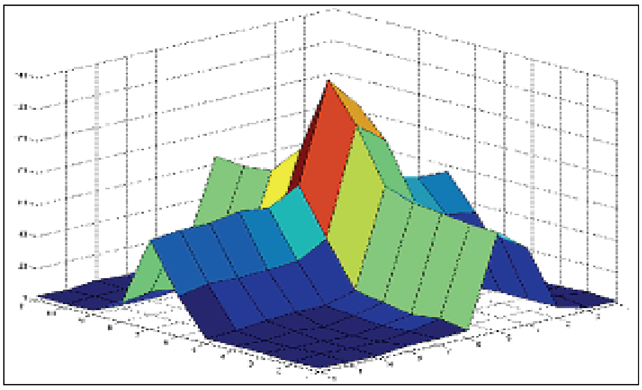


Figure 2: Peak of correlation function

The correlation steps Δi and Δj are the significant value. If Δi and Δj are too high, the peak of correlation function will not be found. Absolute measurement outset from observer view as well as the orientation of absolute coordinate system are significant for the creation of 2D orthogonally environment map by the robot. The first measurement of the laser rangefinder in time t0 defines absolute rangefinder position and subsequently CSA of the whole environmental map. The Robotic undercarriage has the coordinate system CSR for axis calculation. The laser rangefinder pictures in time tt+1…n will be correlated only with the first picture in time t0. Coordinate systems of the robotic undercarriage CSR as well as the laser rangefinder CSLD are identical because of the task simplification.

3 LASER MEASUREMENT SYSTEM AND FILTRATION

The mutual interaction between an unknown space and the robot is provided by the laser rangefinder.This device enables to measure the distances in the flat ground with an accuracy of just a few centimetres. Figure 2 depicts the scan layout. Coordinate systems of the robotic undercarriage CSR as well as the laser rangefinder are identical because of the task simplification. However, if we accept this simplification, the transversal and longitudinal incline of the vehicle will have an impact on an accuracy of the measured data. The distance measurement error will proportionally get bigger with the increasing distance. Therefore, correction – calculation of the measured distance to a real one – is necessary. Measuring by means of laser rangefinders may result in errors caused by reflective properties of materials. These properties have an impact on beam attenuation or dispersion. Incorrect distance measurement usually occurs while measuring objects with glossy or glass surface. This error may be indicated by big fluctuation of a measured distance between a pair of angles. Furthermore, the measurement error can be recognized by maximum positive values, such as maximum range of the rangefinder. The shape of the objects is markedly deformed and it is impossible to determine an exact edge of such objects. Therefore, it is necessary to insert a filter into algorithm before processing of the measured data, e.g. when making a map. Such a filter would eliminate anomalies caused by reflexibility. Figure 3 – demonstration of incorrect distance measurement from a glossy object by means of LMS-291 laser rangefinder. The data measured in this way include big changes of the measured values while the measurement angle is changed to a small extent. The filter uses these characteristic features for detection of a glossy object. At first, the filter counts the changes of distances between every two consecutive measured data. In the second step, it applies a filtration interval with a defined width.

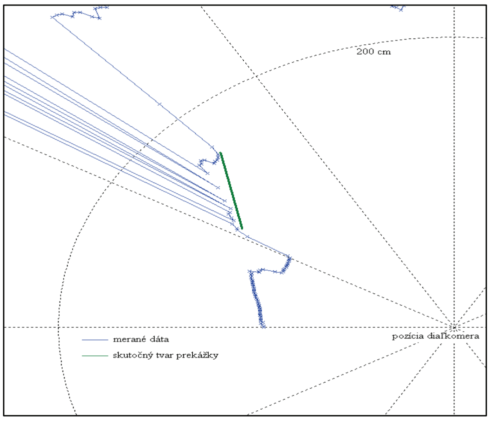


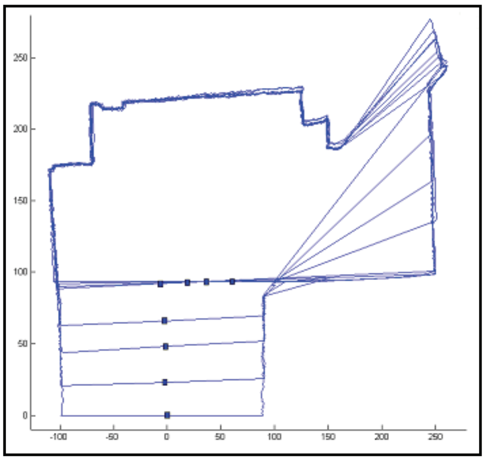
Figure 3: Illustrates an glossy object measured

If this interval includes both positive and negative values of the distance, higher than the defined threshold, all the measured values of the interval are marked as incorrect values.

4 Conclusion

Utilization of the correlation algorithm has been verified for calculation of the robot position by a cognitive sensor. The results of the guide accuracy into the finish point has had value (+ 0.025 m for axis x) and (– 0.056 m for axis y) on the trajectory length 1.750 m.

Figure 4: Calculated position of robot system



Navigation accuracy is determined by correlation step Δi,j. The correlation algorithm of position calculation has included rough and fine correlation step regulation Δi,j in order to achieve the maximum value for certain axis. According to the experiment, this method is computationally undemanding and has efficient utilization for linear translational robot movements in the direction of axis x and y. The possibility of the cognitive sensor utilization in the orientation process has significant asset. In the real case, there is not only translational movement in the direction of axis x and y but also the mutual rotation CS_A and CS_R by the angle $\Delta\alpha$. Coordinate system rotation in the angle $\Delta\alpha$ is critical because the small value $\Delta\alpha$ causes disuse of correlation algorithm. The utilization of secondary sensors for the angle α measurement is the way how to avoid this situation. For instance, sensors of robot movement control – magnetometer, odometric sensor.

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