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ENHANCING ROUTE MAPPING AND LOCALIZATION OF MOBILE ROBOTS

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ABSTRACT

This paper is an overview of image sensors used for fast localization for mobile robotics, which is a basic function within mobile robotics. Mainly image sensors are used besides odometry. These sensors fail to record and model the working environment for operational mobile robots when it comes outgoing from 2D/3D laser scanners over existing 2D-mono/stereo cameras, which is a major problem. This paper introduces 3D-PMD video camera, an efficient image sensor. The sensor can record the robot environment as normal 2D image and delivers deeper information for 3D image. Speed and accuracy concern open possibilities for object and obstacle recognition, localization and autonomous map generation within mobile robotics. The main operational area for mobile robots lies in "Autonomous Guided Vehicles". Localization determines position, orientation and inclination from the starting point. A defined path for mobile robot is determined by starting, intermediate and end points. It must successively drive to these points with the path description and localization. A control algorithm navigates the mobile robot. The algorithm also corrects the position by sensing changes in its speed and direction. With the appearance of an obstacle, object and obstacle recognition sensors navigate the mobile robot to avoid collisions.

Keywords: *Camera, image sensing, Route mapping.*

I. INTRODUCTION

There are many ways for successful 3-D navigation which are developed by nature staring from the insects up to the mammals. In the following research the methods of integration of the PMD technology for use in mobile robotics for 3-D mapping will be presented. Firstly we introduce the PMD functional system and the used robot system to the reader. For exact 3-D mapping with a 3-D vision system in a robot, it isimportant to know the accurate robot position and orientation. For this we need methods for precise self localization. These methods combine information from the wheel encoder of the robot with position data which we calculate from the PMD data. By realizing the self localization will discuss the recording of a colored 3-D Map, to enhance 3-D scenario we combine 2D- PMD camera. We will get the depth data from PMD and counter with depth data by this combination. This data can be easily used in 3-D geometry application.

Odometry

Mobile Robot are in built with iodometry sensor which indicate the distance they had travelled on the basic of the amount that the wheels have turn. Such measurements are not so accurate due to wheel slippage, small modeling error and surface imperfections.

Robot vision

Basically, Robot Vision is using a combination of computer algorithm and camera hardware to allow robots to process visual data from the outside world. For example, use of 2-D camera in our system which detectan object for the robot to pickup robot vision is very necessary because without having robot vision our robot is blind. This is the problem with some applications only not for all robotics tasks.

Robot vision is not mainly engineering domain, it is a science having its own particular areas of research. Robot is its technique and algorithm.

It also involves controlling the motion of a robot as detected by a vision sensor.

II. MOBILE ROBOTS

Now a day the main operational area of mobile robot are in the industry as so called autonomous guided vehicle. AGVs used in a factory building for different type of purpose like – Transport of material and work pieces in the production area without a driving operator. These robot are also used is malls, construction of road, construction of building for transport of materials to the consumers or workers without any driving operation. Today, also in private sector or corporate sectors so called services robots are employed and the create unemployment for a needy.

Example**-** Coffee machine are placed their for the refreshment of the worker so that they can get energized and do their work with full enthusiasm and their are some safety and guard robot are also placed just like entry doors which recognizes any type of illegal material with the person taking entry inside the office.

2.1. Working area of mobile robot

Most of the above described mobile robot exclusive work on even surfaces within building, but a few robots dare themselves into the free hilly area that is outdoor 3-D environment. At present there is no useful robot exist which can navigate several floors connected with stairs, elevators with in a building. This is due to the fact that localization and navigation in robot surrounding field has eminent important in its construction.

2.3. Basic function navigation and services

A mobile robot must contain certain basic function for measurement and control for performing any kind of services and some of the basic function are object recognition, obstacle recognition and obstacle avoidance. The simple services "Search" can be realized. The robot looks for something by standing at its location until the further basic function localization is mentioned. Localization means to know always the position and orientation of the mobile robot including its inclination with the 3-D environment.

Based on the above basic function the services "Cleanliness" can be implemented. Cleanliness means to clean by moving in the surrounding of the robot. During cleaning the robot will explore significant object which are registered into a virtual map as landmark of that environment. For cleanliness task the robot perform some purposeful or coincidental movement while purposeful robot movement it drives on a given path in the unknown surrounding where the coincidental movement is suitable. The further robot movement is done by the change of direction at obstacles and through driving along walls. A mobile robot has to drive through a defined path which is given by the starting point, some intermediate point and the end points. It must successively drive to these points. According to the path if the mobile robot is on the correct points then it is navigated by the path description and the localization through a suitable control algorithm. According to this the control algorithm rectifies the position of mobile robot by changing its speed and direction. The mobile robot must avoid collision on the appearance of an obstacle detected by the obstacle recognition sensor. It is recognized if the obstacles perform a movement itself. In this case the travel of mobile robot is interrupted until the obstacle leaves the path. Otherwise, the mobile robot would leaves its given path with the help of obstacle avoidance function, which drive around the obstacles and then drives back to the original path again and continuous the movements. We can use a map in which all the parts can be drown. With all above described Implementation many useful services can be created. For example observation, cleaning, courier services etc.

III. LOCALIZATION

Locomotion mechanism is needed to a mobile robot for its unbounded movement throughout its environment. There are many varieties of possible ways to move and so the selection of a robot approach to localization is very important aspect while designing mobile robot. In laboratory there are different type of research robot that walk run, jump, slide, skate, fly and roll.

A cleaning robot which always cleans the same area needs changes in relation to the start point. If position and orientation data of that robot is changed it have differently. The absolute values in this case are lengthening and degree of latitude. For example -of a refinery search robot the position and number of found refiners must be indicated in absolute value, for the targeted production plans.

For determining position and orientation of the mobile robot there are numerous but not very accurate sensors are used. For example – Wheel encoder, magnetic compass, inclination sensor, accelerations sensors, LPS (Local Positioning System).

3.1. Localization with odometer

The method in which the evaluation of the wheel encoder impulses in the counted for localization is odometry. For computing new position and orientation of the mobile robot, the geometry of the wheels their distance with each other and the measured wheel encoder impulses sequentially the new position. Localization with wheel encoder represents an integral method in which the incremental changes are sequentially the starting points. Errors due to chutes and sliding of the drive wheels or driving over stage are considered in the computation of location data of the mobile robot.

3.2 Localization with camera

A Video Camera acquires the surrounding of mobile robot with the frame rate of 25 image / sec. The normal mono camera can provide only 2D images in the simplest case. With this camera the depth data of 3-D robot surrounding can not be captured, but

IV. THE CAMERA SYSTEM

Here we have used 3D-PMD camera for the study. Analyzing 2D images is very useful in many machine vision applications however sometimes it is necessary and helpful to create a 3D image of an object. PMD (photonic mixer device) is cost effective alternative option to other 2D-3D measuring systems which include stereo vision system or laser scanners in mobile robot applications. The PMD camera was developed by The University of Siegenand Centre for sensor systems (ZESS). This system is able to capture both depth and intensity information simultaneously for every pixel in the image.

Today various imaging techniques can provide 3D information for machine vision applications. A normal 2D camera captures many images of just the line while the object camera and light is in motion.Other techniques such as time of flight and stereo structured light do not scanning. This is a fast, easy to install and simpler cost effective technique in machine vision applications.

Time of flight is the functional principle of these cameras and acts as a measuring system.

4.1 Time of flight

Time of flight can be defined as the property of the object, particle or acoustic, electromagnetic or other wave which denotes the time taken such an object, particle or wave to travel through medium.

A time of flight-based camera consists of a lens, integrated light source, a sensor that stores all capture image data and an interface. In basic terms a time of flight camera works by first illuminating the scene with a pulsed or continuous wave light source and then observing the reflected light.

Time of flight cameras based on pulsed light sources measure the time it takes for a pulsed light to travel from the emitter to the scene and then back after reflection. As the speed of light is known by using simple algorithms the distance of all the points on the object surface can be determined.

Time of flight cameras using continuous waves detects the phase shift of the reflected light. Modulating the amplitude creates light source of a sinusoidal form with a known frequency. A detector determines the phase shift of the reflected light and again using simple algorithms a dept for each point can be calculated.

4.2 Omni-directional camera

In terms of photography, an omnidirectional camera can be defined as the camera which has the capability of capturing light rays covering approximately the entire sphere or at least a full circle in the horizontal plane because of its 360 degrees field of view.

These cameras have found immense importance in working areas where coverage of large visual is required such as robotics and panoramic photography. Normally cameras have field of view ranging for few degrees to at most 180 degrees. This means they can capture light rays which are falling on the camera focal point through a hemisphere only. On the other hand, an ideal omnidirectional camera has the capability of capturing light rays from all directions falling on to the focal point, thus forming a full sphere coverage.

But in practice many cameras which are referred to as omni directional can cover only hemisphere approximately or they can cover the full 360 degrees along the equator but not the top and bottom of the sphere. This is because in the process of capturing light rays from whole sphere, the captured light rays many times do not exactly intersect onto single focal point.

V. LOCALIZATION WITH 3D-PMD CAMERA

First, the robot searches for the relation between the global 2D map and 3D snapshot captured by 3D camera while the robot in motion. Then the 3D snapshot is converted into 2D snapshot for the projection of all height and depth related data of natural landmarks on the floor surface. In order to generate, a sub 2D map these natural landmarks which include corners and edges of objects are connected through lines to get the rough idea about orientation and position of object. The localization process when the image processing system starts searching for the objects and their characteristics according to represented 2D sub map inside the global 2D map. Through translation, rotation and scaling the adaptation of global 2D is done. According to position and orientation of the robot the values for translation and orientation is searched.

5.1 Simultaneous localization and map building using PMD camera

A virtual map based on natural landmark of the environment is generated by the mobile robot. These natural landmarks are different in geometry, texture and color when compared with virtual map. For simultaneous localization and map building it is crucial that fast and direct information is processed when the mobile robot is in motion.

A 3D-PMD video camera is mounted on the mobile robot in the main direction of robot's movements. The mobile robot starts moving from the given starting point and keeps on exploring the still unknown area. From different positions of working environment 3Dsnapshots are captured by the camera when the robot is still exploring the unknown area.

The camera mounted on the mobile robot is so adapted with the movement, that it provides enough overlap of the 3D snapshots during the exploration of area. According to acquired information about 3D depth and overlapping of snapshots a enough information is gathered for the calculation of new orientation and position of the mobile robot. The data 3D snapshots along with this calculated position and orientation are together registered into the virtual map, considering the overlap of snapshots. The entire virtual map grows piece by piece using this simple technique. Now the captured 3D snapshots are combined for complete 3D map generation.

5.2 Simultaneous localization and map building using omni directional camera

In such cases, the mobile robot uses an omnidirectional camera with a 360 degrees field of view and a sealed cone, for the generation of map. The camera is mounted on the sealed cone. Recording and capturing of images while exploration depends upon contour of sealed cone. For the generation of map, localization and navigation the entire working environment can be spatially recorded as panorama images. These panorama images are available as 3D as well as 2D images and according to the contour of the sealed cone these images must be equalized to start the process of map generation. The camera captures several panorama images from different locations during the exploration of unknown area. Then 3D image data is merged together to get a virtual 3D map. During the recording of panorama images covered and unidentified areas are avoided by camera, resulting in generation of virtual 3D map which is location independent.

VI. CONCLUSION

In this paper, the 3D map building and self-localization for mobile robots with the integration of 3D PMD camera in combination with normal CCD sensors and 3D PMD sensors is described. The data calculated from 3D images for the combination of image vectors and normal wheel encoders, could be verified for providingbetter possibilities of determining relative position of the working mobile robot. For successful map building, an excellent basis is provided by integrating relative self-localization and absolute self-localization. The performance of 3D PMD cameras can be enhanced by combining them with 3D/2D camera. It can be used for determining the third dimension of the working environment and can also be applied for object detection and for avoiding obstacles where the working environment is complex and unfamiliar to operator. With the availability of color-coded information for distance inside the map the map interpretation becomes easy for the operator. The only prominent problem which occurs during the map building, is due to the small field of view of PMD cameras. Because of small field of view only one side results (either of right side or of left side) could be expressed at a time and in order to generate the map of the other side the camera needs to be turned on one side else the surrounding area will not be recorded for map generation.

To over come the above defined resolution problem is to integrate the rotating mechanical part which is capable of rotating the camera from 0 to 180 degrees and this could probably improve the 3D image quality. Another possible solution for this problem is more than one camera should be mounted on mobile robot one in front and one at each corner of the robot.

The 3D video cameras available today have fellow characteristics:
(A) Resolution- 16(V)*64(H)
(B) Pixel- z-resolution>*5mm*
(C)Field of view- 34 degree (H) to 12 degree (V)
(D) frame rate up to 50 fps
(E) data format- 8 bit for 3D and 8 bit for grey scale imaging

With the advancements in technology it could be expected that these cameras will have frame rate up to 100fps and increase pixel array up to 120x160 in near future and may receive VGA format later. These exact 3D maps and fast localization are the basis for complex real time services such as search, rescue, observation, exploration, cleaning, inspection etc. which will be the future task for mobile robots

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