ROBUST OBSTACLE AVOIDANCE USING STRUCTURED LIGHT

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In this paper we present a low cost system for obstacle avoidance, using structured light. Service robots, such as robots working in a home environment, need very robust, reliable and at the same time low cost sensing mechanisms. Several types of sensors and methods can be used to inform a robot of its surroundings, the most popular sensors are ultrasonic and infrared range finders, laser scanners for active methods of sensing and computer vision for passive sensing.

Robot vision is a passive sensing example. It is based on image-processing techniques that analyze texture, linear perspective, motion, focus, occlusion and etc. It is rapidly developing field, though vision systems for robust obstacle avoidance are far from ideal, they generally require much computations and processing, to perform well in real time. The power and equipment needed for such processing would also contribute significantly to the load and the cost of the robotic system.

While passive sensing uses the already illuminated scene to detect depth. Active sensing involves a transmission of energy, such as acoustic or electromagnetic waves which returns reflections from an obstacle to a sensor. Such sensors as ultrasonic and infrared range finders are popular in robotics, however they have a number of limitations.

The ultrasonic sonar is low cost, easy to use sensor, in a certain range provides reliable distance measurement. However, at a long distance, the ultrasonic signal attenuates significantly. The speed of ultrasonic wave is roughly 330 m/s, therefore systems based on this principle are delayed by the reflected response. Ultrasonic sensor has a wide-angle beam, this creates ambiguity of precise location of the objects in the field of view. The use of ultrasonic sonar is limited to certain areas due to the reflectivity and absorption of surfaces since certain surfaces absorb ultrasonic waves, while others reflect it to a higher degree. This problem is known as surface interaction. Light, sound, or radio waves strike an object, any detected echo represents only a small portion of the original signal. The remaining energy reflects in scattered directions and can be absorbed by or pass through the target, depending on surface characteristics and the angle of incidence of the beam. Instances where no return signal is received at all can occur because of specular reflection at the object's surface, especially in the ultrasonic region of spectrum, due to its relatively long wavelength.

Infrared range finders is based on optical triangulation and utilizes electromagnetic waves in a range around 850nm. Pulse of light is emitted and then reflected back (or not reflected at all). When the light returns it comes back at an angle that is dependent on the distance of the reflecting object. Triangulation works by detecting this reflected beam angle. By knowing the angle, distance can then be determined. Since infrared range finders utilizes the electromagnetic waves with shorter wavelength, they suffer less from surface interaction problem. This ranging method is almost immune to interference from ambient light, and is almost indifferent to the color of the object being detected. However, the operating range of such sensors is normally limited by range from 100mm to 800mm. Another problem is a high narrowness of the IR beam. Thin beam can detect an obstacle if it is pointed exactly at the object, otherwise the object is invisible. For indoor environment this problem is crucial, hence objects such as chairs and tables have thin legs and could be missed by the sensor with a narrow beam. This problem is solved by currently developed Hokuyo PBS-03JN Infrared Range Finder, which is able to report distances from 200mm to 3000mm in a 178.2° arc (1.8° angular resolution). This sensor is comparable with a laser scanner, and is used in advanced robots for map building and localization. Main disadvantage of this sensor is relatively high price for low cost service robotics.

Structured light is another active sensing technique well known in 3D scanning. Structured light sensor is similar to a classical stereoscopic sensor with one camera replaced by a light source. In its

simplest form, structured light is a laser beam projecting a single dot or a line into the scene in visible or near infrared spectrum. A camera is oriented down towards the object, while a laser source is directed such that its beam intersects the object. To determine the distance to the object, triangulation is used between the camera, the object, and the light source. The advantages are that structured light system utilizes shorter electromagnetic waves compare to ultrasound range finder, has a beam wider then the IR sensor and requires less computational power compare to computer vision systems. Therefore, the use of structured light could be a potentially valuable solution for a low cost robotics.

The goal of this project is to design a reliable and low cost system for obstacle detection based on a structured light projector and a camera. Physical model of the sensor have been developed and tested in the simulation and implemented in the hardware. Set of experiments has been performed to verify simulated data and estimate system reliability.