AUTOMATIC OBSTACLE DETECTION BASED ON GAUSSIAN FUNCTION IN ROBOCAR

Debabrata Samanta *

Arya Ghosh **

ABSTRACT

Robocar is the world's best invention for human generation in today's life. A car miniature prototype car research by us who's various movements can be controlled automatically. Considering the road knowledge, we develop a new approach to extract the position of the obstacles and respond immediately in accordance with the obstacles, based on its geometric features.

* Lecturer, Department of CSE, National Institute of Technology, Durgapur, West Bengal, India.

** Department IT, Bengal Engineering and Science University, Shibpur, Howrah.

I. INTRODUCTION

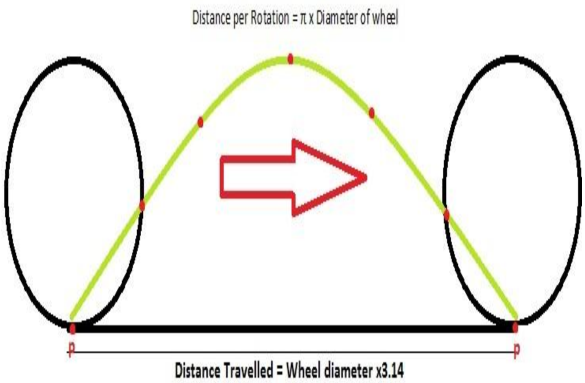
ROADS, as one of the most important man-made objects, are of great significance in landscape and transportation. Urban road information extraction plays a critical role in GIS data update, image matching, object detections and finite element analysis, etc. It's a great challenge to drive cars in hilly areas, due to falling rocks on roads without any stipulated warning. After any activity neuron takes 10^{-3} seconds to reach to the human brain and respond accordingly. As much as humans need sensors for making impressions of the world around, to navigate freely without colliding and sometimes even to localize ourselves with reference to the world around, robots need them for same reasons.

Applications for imaging in automobiles include assistance in blind-spot viewing, lane-departure warning systems, and automatic headlight dimming. Rear, corner, and blind-spot viewing systems are the most common use of cameras in cars today. They are found in the Toyota Prius and as an option in Lexus models, where a back-up camera provides another perspective for the driver. With the rapid growth of road related services, such as navigation systems, telematics, and location-based services, the efficient extraction of road information is in urgent need nowadays. The high population growth and therefore high growth in road traffic volume over the last decades have increased road traffic to its congestion level. This poses great challenges on today's road traffic research and planning. Vehicle monitoring is one of the important issues to plan solution for the traffic congestion problem. A robot can be defined as an electro-mechanical system with the capability of sensing its environment, manipulating it and acting according to the pre-programmed sequence. It is a machine that appears intelligent due to the instructions it receives from a computer inside it which handles multiple tasks.

In this paper we proposed a novel methodology to detect the obstacle (coming suddenly in front of a car) in three steps: First: Measurement of distance between obstacle and car. Second: Length and height of the obstacle. Third: Generate the angle and move accordingly.

II. RELATED WORK

For the complexity of hilly road system, using remotely sensed images to recognize and extract road network has been a cutting-edge problem in remote sensing and related fields (Shi, 2001; Gong, 2006). Many researches have done on the topic and achieved abundant results. However, existed road extraction methods still have problems in popularization and application: the extraction accuracy cannot satisfy the needs of engineering application; the automation is in a relatively low level; the performance is limited by either road materials or complex road networks. Shi and Mena had reviewed some of these approaches (Shi, 2001; Mena, 2003). Present main approaches are those like dynamic programming (Gruen, 1995), texture analysis applied to a single layer, Snakes (Trinder, 1995), mathematical morphology based on geometric shape (An, 2003; Zhu, 2004). All these models or algorithms are mainly based on radiometric characteristics and geometric constraints of road information in the imagery thus do not exploit fully the spectral information of roads. For one thing, abundant ground targets within or beside roads cause too many non-road speckles or mixed pixels, and the road targets are correspondingly broken and inconsistent to a large extent, which render the pre-process of these methods hard to reach a satisfactory accuracy, let alone the further process; for another thing, these methods fails to take a frequently-seen phenomenon of shadows on roads into account, thus they are unable to extract roads covered by shadows.



This paper presents a novel approach to drive a car smoothly also in presence of obstacle.

III. PROPOSED METHODOLOGY

The approach includes both spectral and geometric constraints about roads network in urban areas. The methodological framework contains three steps: rough classification, road connection, and result grooming.

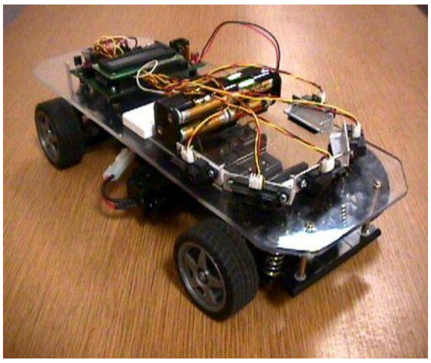


Fig1:- Model RoboCar

Road Feature Analysis: In high spatial resolution remotely sensed images, hilly roads have following properties.

***Stability of spectral property*:** The spectral properties of uncovered roads are stable to a certain degree. Because urban roads are mainly constructed by asphalt or cement, especially asphalt dominates a large part; spectral properties of roads are limited to a fixed range which corresponds to the spectral range of road materials. However, in the imagery, objects on roadsides like zebra crossings, cars and people cause noises due to the huge spectral difference to roads.

***Continuity of roads*:** Normally roads in reality are continuous and regular in geometry, while in the imagery, trees and shadows of high buildings by roads interrupt the continuity of roads to a large degree. But on the whole, roads in the imagery still have impressive connection and regularity.

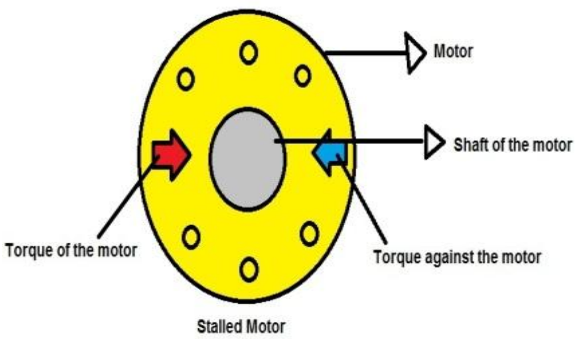
Straightness: On high spatial resolution images, urban roads are straight and smooth with no small wiggles thus can be recognized as combinations of straight road segments.

***Topological property*:** Road segments are always connected with each other constituting road networks, and impossible to be broken suddenly.

***Velocity**:* Velocity is the distance travelled in unit so the units are meters per second or kilometres per hour etc. and that distance is the product of the diameter and π (π=3.14). The total distance travelled per minute.

Speed of Bot = RPM x Distance per rotation

Stall Torque: A motor shouldn’t be left in stalled condition for a long time you will end up losing the motor.

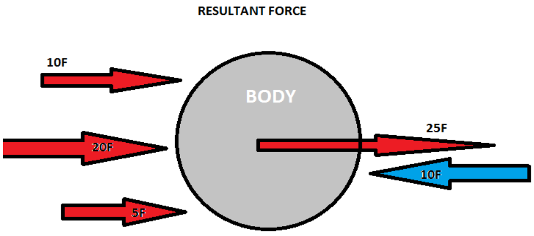


Traction:

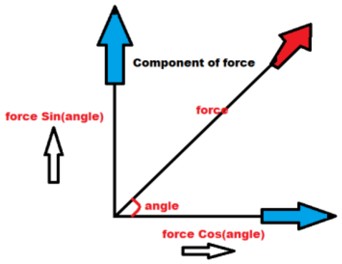
Traction is the maximum frictional force that can be produced between two surfaces without slipping. i.e. The force that prevents our robot from sliding off.

F = m.a (mass x acceleration)

Calculating forces is a must when you build your Robot! Let’s get through the basics once. Every time we consider a set of forces we need to get the resultant force and its value to know how the body experiencing the force will behave. Look at the diagram below to understand.



Component of Force

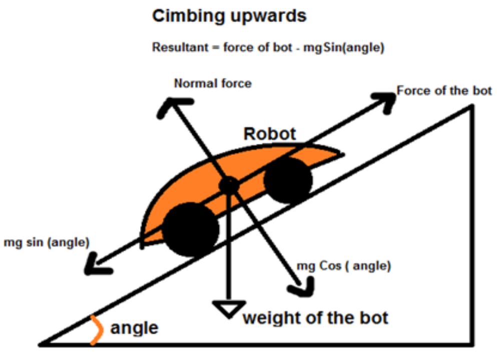


So in general when the force is acting at an angle as shown in the figure the force along the direction of movement can be found out by resolving it into its components like shown in the above diagram.

Force of Gravitation: This is the force that is applied on the body directed towards the centre of the earth. This force is equal to the weight of the body (f=m.a; a=9.8 m/s^2; f=m.g)

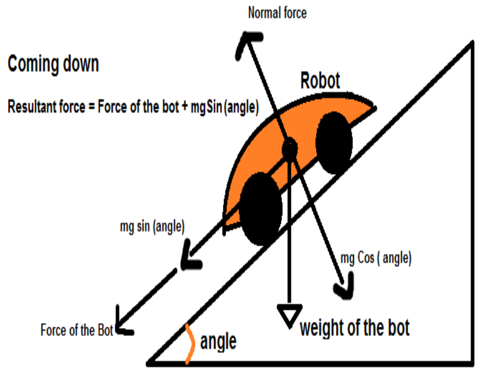
IV. CALCULATING FORCES ON INCLINES

UP the INCLINE**:** When climbing up the incline a component of the gravitational force acts against us so the force we have on the robot is reduced by this component as it acts in the opposite direction of the force we are applying to get our bot to the top the diagram below ill make it clear.



When coming down the incline the component acts along with you so the force increases.

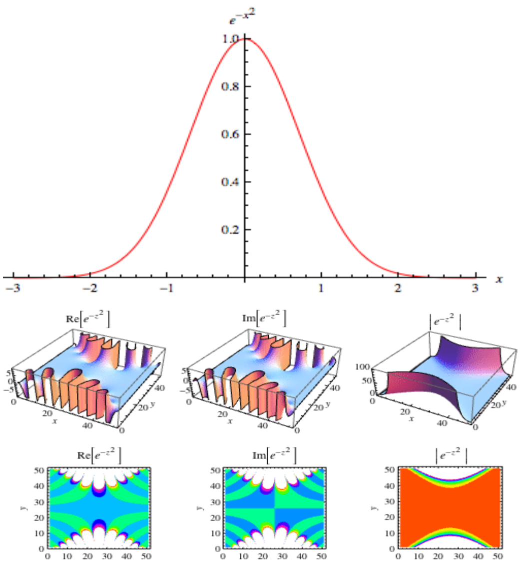
Look at the figure below so get a clear picture



Friction on inclines:

Sometimes your bot might start slipping on inclines this is because the magnitude of the component of weight is greater than the force of friction in between the tyres and the surface of the inclines.

V. OBSTACLE MEASUREMENT BASED ON GAUSSIAN FUNCTION



In one dimension, the Gaussian function is the probability density function of the normal distribution,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/(2\sigma^2)}$$

Sometimes, also called the frequency curve. The full width at half maximum (FWHM) for a Gaussian is found by finding the half-maximum points. The constant scaling factor can be ignored, so we must solve

$$e^{\frac{-(x_0-\mu)^2}{(2\sigma^2)}} = \frac{1}{2} f(x_{\max})$$

But $f(x_{max})$ occurs at $x_{max}=\mu$, so

$$e^{\frac{-(x_0-\mu)^2}{(2\sigma^2)}} = \frac{1}{2} f(\mu) = \frac{1}{2}$$

Solving,

$$e^{\frac{-(x_0-\mu)^2}{(2\sigma^2)}} = 2^{-1}$$

$$\frac{-(x_0-\mu)^2}{(2\sigma^2)} = -\ln 2$$

$$(x_0-\mu)^2 = 2\sigma^2 \ln 2$$

$$e^{\frac{-(x_0-\mu)^2}{(2\sigma^2)}} = \frac{1}{2} f(x_{\max})$$

The full width at half maximum is therefore given by

$$\text{FWHM} \equiv x_+ - x_- = 2\sqrt{2\ln 2}\,\sigma \approx 2.3548\sigma$$

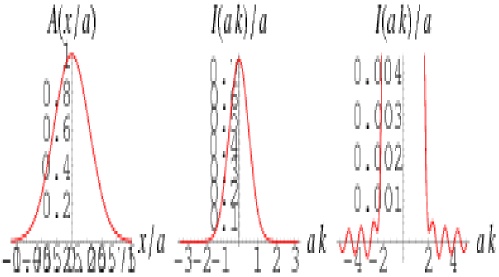
$$x_0 = \pm\sqrt{2\ln 2} + \mu$$

In two dimensions, the circular Gaussian function is the distribution function for uncorrelated variants X and Y having a bivariate normal distribution and equal standard deviation,

$$\sigma = \sigma_x = \sigma_y \quad f(x,y) = \frac{1}{2\pi\sigma^2} e^{-[(x-\mu_x)^2+(y-\mu_y)^2]/(2\sigma^2)}$$

The corresponding elliptical Gaussian function corresponding to $\sigma_x \neq \sigma_y$ is given by

$$f(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{-[(x-\mu_x)^2/(2\sigma^2{}_x)+(y-\mu_y)/(2\sigma^2)]}$$



The Gaussian function can also be used as an apodization function

shown above with the corresponding instrument function. The instrument function is

$$I(k) = e^{-2\pi^2 k^2 \sigma^2} \sigma \sqrt{\frac{\pi}{2}} \left[erf\left(\frac{a - 2\pi i k \sigma^2}{\sigma\sqrt{2}} \right) + erf\left(\frac{a + 2\pi i k \sigma^2}{\sigma\sqrt{2}} \right) \right]$$

which has maximum

$$I_{\max} = \sigma\sqrt{2\pi}\, erf\left(\frac{a}{a\sqrt{2}} \right)$$

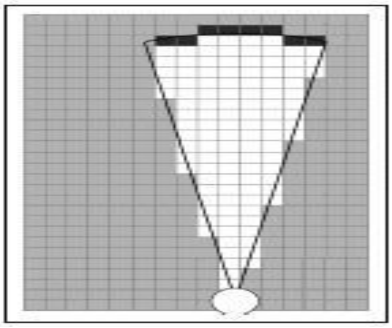
As $a \to \infty$, equation (12) reduces to

$$\lim_{a\to\infty} I(k) = \sigma\sqrt{2\pi} e^{-2\pi^2 k^2 \sigma^2}$$

The hyper geometric function is also sometimes known as the Gaussian function.

Signal coming from car:

Electromagnetic signal is coming from car and detecting the obstacle.



When the sensor starts scanning, each cell/pixel contained in this conical area is set to probability of occupancy accordingly as per object position. When the radial distance increases, the probability value increases. The below figure will give an idea of how the probability value is described in the conical area from the region close to the robocar to the region far away from the robot, when no obstacle is sensed. Note that the variance in the probability is dependent on the angular factor as well.

When there is an obstacle in the conical area, then

CONCLUSION

The proposed approach of automatic extraction of obstacle detection from high spatial resolution obstacle images can improve the accuracy of road extraction and move the robocar accordingly. At first we measure the distance between obstacle and car, after that calculate length and height of the obstacle using Gaussian function. Finally generate the angle and move accordingly. So this preliminary study indicated that the proposed strategy was effective.

REFERENCES

1. Adams, M.D., Sensor Modelling, Design and Data Processing for Autonomous Navigation. World Scientific Series in Robotics and Intelligent Systems. Singapore, World Scientific Publishing Co. Ltd., 1999.
2. Probabilistic Robotics by Thrun Burgard Fox.
3. Breipohl, A.M., Probabilistic Systems Analysis: An Introduction to Probabilistic Models, Decisions, and Applications of Random Processes. New York, John Wiley Sons, 1970.
4. Everett, H.R., Sensors for Mobile Robots, Theory and Applications. New York, Natick, MA, A.K. Peters, Ltd., 1995.
5. Lee, D., The Map-Building and Exploration Strategies of a Simple Sonar-Equipped Mobile Robot. Cambridge, UK, Cambridge University Press, 1996.
6. Lumelsky, V., Skewis, T., "Incorporating Range Sensing in the Robot Navigation Function." IEEE Transactions on Systems, Man, and Cybernetics, 20:1990, pp. 1058–1068. [2]. Elfes, A., "Sonar-Based Real World Mapping and Navigation,"
7. Lazanas, A. Latombe, J.C., "Motion Planning with Uncertainty: A Landmark Approach." Artificial Intelligence, 76:285–317, 1995.
8. Burgard, W., Fox, D., Jans, H., Matenar, C., Thrun, S., "Sonar-Based Mapping of Large-Scale Mobile Robot Environments using EM," in Proceedings of the International Conference on Machine Learning, Bled, Slovenia, 1999.

9. Jin, X., and Davis, C. H. (2007). “Vehicle detection from high-resolution satellite imagery using morphological shared-weight neural networks,” *Image Vis. Comput*., vol. 25, no. 9, pp. 1422–1431, Sep. 2007.
10. Vosselman, G., De Knecht, J., 1995 Road tracking by profile matching and Kalman filtering. Workshop on Automatic Extraction of Man-Made Objects from Aerial and Space Images, pp. 265–274.
11. Zhang, Y.S., GONG, D.C, et al, 2004 Application of High Spatial Resolution Remotely Sensed Imagery, *Science Press,* Beijing.