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RASPBERRY PI VEHICLE WITH STEREO VISION

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Abstract— **This Project presents an approach to stereovision applied to vehicles. By using a small low cost computer and inexpensive off the shelf components, we were able to develop an autonomous driving system capable of following other vehicle and moving along paths delimited by colored blobs. Pair of webcams was used and are able to implement a basic frontal obstacle avoidance system. With the help of the stereoscopic system, we inferred the position of specific objects that serve as references to the Vehicle. The final system is capable of identifying and following targets in a distance of over 5 meters. Stereo vision deals with two images. The two images captured with a distance between the two cameras called Disparity. Disparity means Difference. Disparity map is a measurement of difference between two things (Images).**

The Model B Raspberry PI is a 3.5W, computer with a 700 MHz ARM1176JZF-S processor and multiple I/O interfaces. The two webcams mounted in this assembly use the two available USB ports and the motors are connected to the General Purpose Input/output pins. We use Open CV Libraries to process Images.

Index Terms—**Raspberry Pi, Stereo Vision, Color Recognition, Object Following.**

I. INTRODUCTION

Computer vision is one of the most demanding areas in the robotic field. A robot is a programmable multifunction manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.

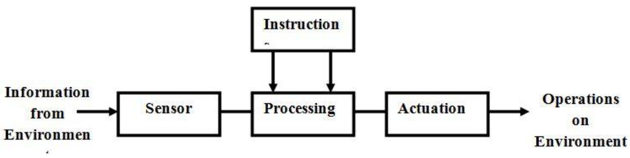

Fig 1: Overview of major components of Robotic system

The processing component is the heart of the system, controlling precisely what actions the system is to execute. The sequence of instructions, although initiated and interpreted by the processing unit would require considerable complexity in the actuators to execute the instructions. The information from the sensing unit is little but in more sophisticated systems the sensing unit could be the key to the entire operation. In this paper, the sensing unit is a pin hole camera which captures the information from environment. The task of the system might be to perform, under the control of the processing unit.

II. OPENCV LIBRARIES

Open Source Computer Vision is a library of programming functions mainly aimed at real-time computer vision. Computer Vision is a scientific field which attempts to provide a sight to the machine. An improvement of vision algorithms and among the computer vision hobbyists is due to the cheaper hardware components and processing power. OpenCV library has multi-platform availability, and it supports a wide variety of programming languages like C++, Python, and Java. As compared to other languages like C/C++, Python is slower. But another important feature of Python is that it can be easily extended with C/C++. This feature helps us to write computationally intensive codes in C/C++ and create a Python wrapper for it so that we can use these wrappers as Python modules. The two advantages are, our code is as fast as original C/C++ code (since it is the actual C++ code working in background) and it is very easy to code in Python. The support of Numpy makes the task easier. Numpy is a highly optimized library for numerical operations. It gives MATLAB-style syntax. All the OpenCV array structures are converted to-and-from Numpy arrays. So whatever operations you can do in Numpy, you can combine it with OpenCV. Besides that, several other libraries like SciPy, Matplotlib which supports Numpy can be used with this.

OpenCV provides a set of modules that can execute roughly the functionalities listed below:

- Core: This module includes core data structure, data types and memory management.
- Imgproc: This module is an image processing module. Image filtering, geometric image transformations, structure and shape analysis.
- Video: video analysis module that includes motion analysis, background subtraction, and object tracking algorithms.
- Calib3d: This module includes basic multiple-view geometry algorithms, single and stereo camera calibration, object pose estimation, stereo correspondence algorithms, and elements of 3D reconstruction.
- features2d: This module includes salient feature detectors, descriptors, and descriptor matchers.
- Objdetect: Object detection using cascade and histogram of gradient classifier. Object module that uses to recognize face, eyes, etc.
- Highgui: This module contains user interface GUI, reading and writings images and video.

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- Nonfree: Implementation of algorithm that are patented in some countries.

OpenCV have a wide range of applications some of which are Stereo Vision, Egomotion estimation, Facial and Gesture Recognition system, Human-Computer Interaction, Mobile Robotics, Motion and object Identification, augmented reality.

III. COLOR DETECTION

Color provides powerful information for object recognition. Commonly used well-known color spaces include: (for display and printing processes) RGB, CMY; (for television and video) YIQ, YUV; (standard set of primary colors) XYZ; (uncorrelated features) I1I2I3; (normalized color) rgb, xyz; (perceptual uniform spaces) U*V*W*, L*a*b*, Luv; and (for humans) HSI. Although, the number of existing color spaces is large, a number of these color models are correlated to intensity I: Y, L* and W*; are linear combinations of RGB: CMY, XYZ and I1I2I3; or normalized with respect to intensity rgb: IQ, xyz, UV, U*V*, a*b*, uv. Therefore, in this paper, we concentrate on the following standard, essentially different, color features are intensity I, RGB, normalized color rgb, hue H and saturation S.

Unlike RGB, HSV separates luma or the image intensity from chroma or the color information. This is very useful in many applications. For example, if we are required to achieve histogram equalization of a color image, then we probably perform operations only on the intensity component, and leave the color components alone, otherwise it results in strange colors.

In computer vision, color components are separated from intensity for various reasons, such as robustness to lighting changes, or removing shadows. In this paper, color detection is achieved by using OpenCV libraries. The function cvtcolor in OpenCV has four arguments they are source, destination, code and destination channel. This will help in converting an RGB image to HSV image. A range should be defined for a particular color to be detected in HSV.

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$$V \leftarrow \max(R,G,B)$$

$$S \leftarrow \begin{cases} \dfrac{v-\min(R,G,B)}{V} & if \;\; v \neq 0 \\ 0 & \text{otherwise} \end{cases}$$

$$H \leftarrow \begin{cases} 60(G-B)/(V-\min(R,G,B)) & \text{if V=R} \\ 120+60(B-R)/(V-\min(R,G,B)) & \text{if V=G} \\ 240+60(R-G)/(V-\min(R,G,B)) & \text{if V=B} \end{cases}$$

In python, the OpenCV libraries should be imported to to perform image operations. The function cv.cvtColor is used to convert RGB to HSV colorspace. To check the range of the color i.e. both lower and upper threshold values, cv.inRange function is used.

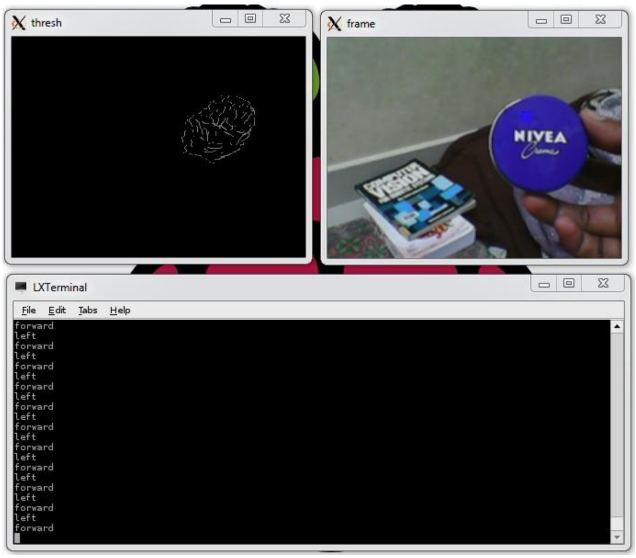

Fig 2: Colored Object Detection on Raspberry Pi

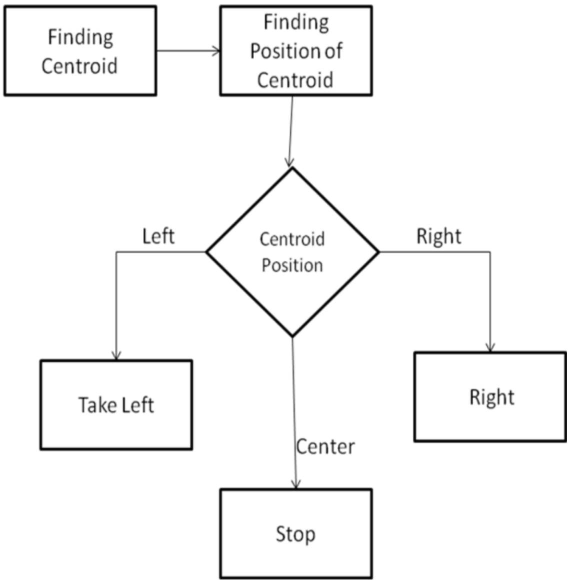

Fig 3: Vehicle guidance with centroid as reference

IV. STEREO VISION

Stereo vision is a technique aimed at inferring depth from two or more cameras and is one of the key subjects in computer vision research. Stereo vision can be best described as taking two viewpoints in a 3D world, comparing the distance between the positions of an object in both images and relating that to the distance of the object to the camera. Such information is retrieved by a dense stereo algorithm of which the output is often a disparity depth map. A disparity depth map is a 2D image where the color of each pixel represents the distance of that point to the camera. In other words, light pixels are near and dark pixels are far.

Depth maps are interesting because they can be used for various purposes:

1. 3D modeling of 2D images when you take two 2D images of a 3D environment and calculate the depth map, you can create a 3D model of the scene by using the depth as the third dimension.
2. Tracking of objects when you have a depth map it is easier to track an object because you have additional segmentation possibilities. You can

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create segments of pixels that are near based on the depth of the pixels and their adjacency.

3. Recognizing front objects when you apply segmentation based on the depth map, you can distinguish objects that are situated in the front of the scene.
4. As information about the environment in path planning depth map supplies additional information for path planning.

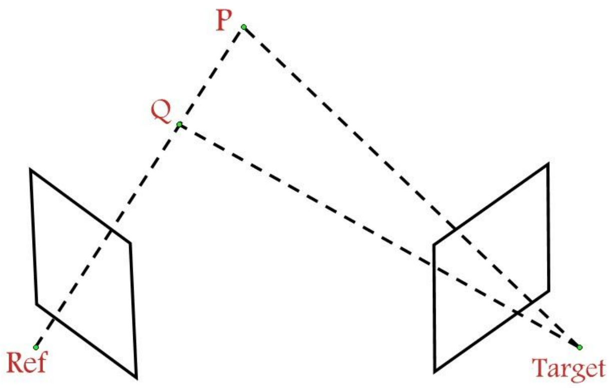

Fig 4: Stereo View to infer the depth

The view from single camera from reference point will lose the information which is in the line of sight of Q. To overcome the limitation of single camera, we use two cameras at different positions so that we don't lose any information which is required to generate the depth map.

When working with stereo vision we need to know the spatial relation between the two cameras, and we need to get rid of radial distortion due to the imperfections of the lens. We can automate this process by showing both cameras different orientations of a chessboard. A simple contrast based algorithm can recognize the black-white intersections of the chessboard squares. The chessboard used can be of any size N by M. This way for each chessboard we show we have N*M points we know for both cameras. Using the disparities of these points between both cameras, we can calculate a rotation/translation matrix which transforms the coordinate system of the left camera to the coordinate system of the right camera, or the other way around.

Fig 5: Stereo Images of a scene

Fig 6: Rectified Stereo Images (Red - Left Image, Cyan - Right Image)

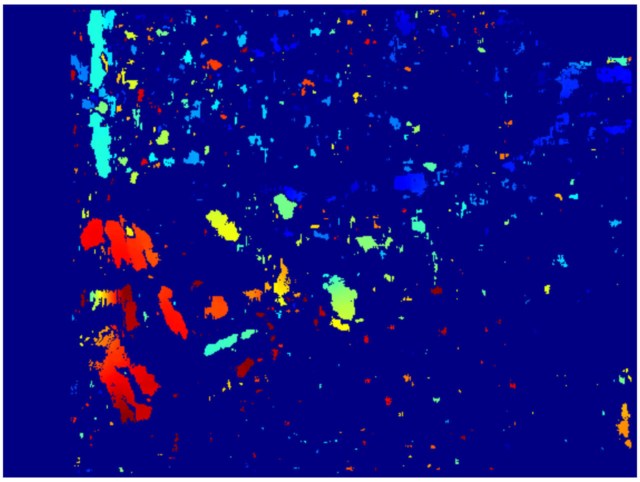

Fig 7: Disparity Map of the scene

V. RASPBERRY PI

The Raspberry Pi is a series of credit card-sized single-board computers. The original Raspberry Pi is based on the Broadcom BCM2835 system on a chip (SoC),which includes an ARM1176JZF-S 700 MHz processor, VideoCore IV GPU,[8] and was originally shipped with 256 megabytes of RAM, later upgraded (models B and B+) to 512 MB. The system has Secure Digital (SD) (models A and B) or MicroSD (models A+ and B+) sockets for boot media and persistent storage. In the Raspbian Linux distro the overclocking options on boot can be done by a software command running "sudo raspi-config". It can be connected to a network using an external user-supplied USB Ethernet or Wi-Fi adapter but later versions have the Ethernet port provided by a built-in USB Ethernet adapter. The Raspberry Pi primarily uses Linux kernel based operating systems.

The Vehicle control is done using Python programming with the motors connected to the General purpose Input Output pins. GPIO pins can be configured as either general-purpose input, general-purpose output or as one of up to 6 special alternate settings, the functions of which are pin dependant. There are 3 GPIO banks on BCM2835. Each of the 3 banks has its own VDD input pin. On Raspberry Pi, all GPIO banks are supplied from 3.3V. Connection of a GPIO to a voltage higher than 3.3V will likely destroy the GPIO block within the SoC. A selection of pins from Bank 0 is available on the P1 header on Raspberry Pi. The GPIO connections on the BCM2835 package are sometimes referred to in the peripherals datasheet as "pads" - a

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semiconductor design term meaning "chip connection to outside world". The pads are configurable CMOS push-pull output drivers/input buffers. Register-based control settings are available for

1. Internal pull-up / pull-down enable/disable
2. Output drive strength
3. Input Schmitt-trigger filtering
4. POWER-ON STATES

All GPIOs revert to general-purpose inputs on power-on reset. The default pull states are also applied, which are detailed in the alternate function table in the ARM peripherals datasheet. Most GPIOs have a default pull applied.

Each GPIO pin, when configured as a general-purpose input, can be configured as an interrupt source to the ARM. Several interrupt generation sources are configurable:

1. Level-sensitive (high/low)
2. Rising/falling edge
3. Asynchronous rising/falling edge

Level interrupts maintain the interrupt status until the level has been cleared by system software (e.g. by servicing the attached peripheral generating the interrupt). The normal rising/falling edge detection has a small amount of synchronization built into the detection. At the system clock frequency, the pin is sampled with the criteria for generation of an interrupt being a stable transition within a 3-cycle window, i.e. a record of "1 0 0" or "0 1 1". Asynchronous detection bypasses this synchronization to enable the detection of very narrow events. Almost all of the GPIO pins have alternative functions. Peripheral blocks internal to BCM2835 can be selected to appear on one or more of a set of GPIO pins, for example the I2C busses can be configured to at least 3 separate locations. Pad control, such as drive strength or Schmitt filtering, still applies when the pin is configured as an alternate function.

A static IP address is given to the Raspberry Pi which is declared in the cmdline.txt file in Raspbian Operating systems. Raspberry Pi can be accessed via Ethernet or WiFi using Remote Desktop Connection, PuTTY and Xming are to allow us to control the terminal and graphical programs directly from your laptop/computer. The Pi can be accessed by using the static IP address assigned to it. The default login name and password are used.

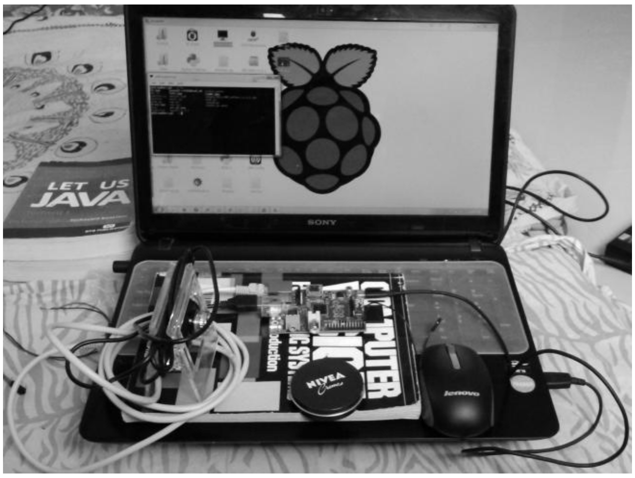

Fig 8: Raspberry Pi Setup

VI. RASPBERRY PI VEHICLE

Stereo vision is highly important in fields such as robotics, to extract information about the relative position of 3D objects in the vicinity of autonomous systems. The most prominent application fields are medical computer vision or medical image processing. This area is characterized by the extraction of information from image data for the purpose of making a medical diagnosis of a patient in detection of tumors. A 3D stereo display finds many applications in entertainment Support of visual effects creation for cinema. Space exploration is already being made with autonomous vehicles using computer vision, NASA's Mars Exploration Rover and ESA's ExoMars Rover. The Development of Autonomous System to build 3D Model for Underwater Objects Using Stereo Vision Technique.

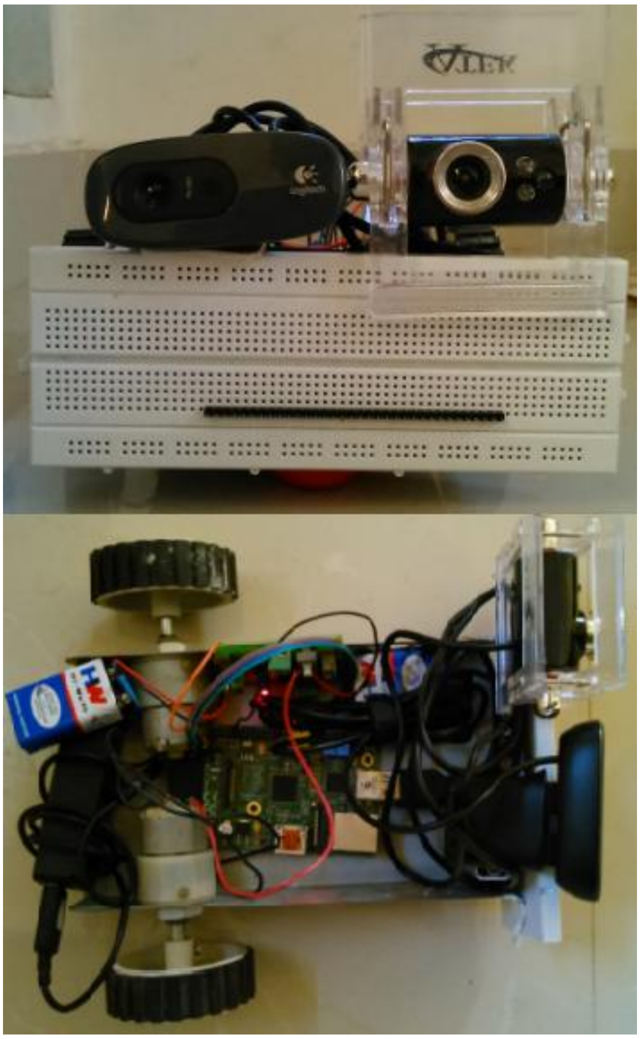

Fig 9: RPi Vehicle with Stereo Vision

VII. CONCLUSION

With this work, it's been proven that it there is the possibility of performing stereoscopic image processing using low cost computational units. Although using more dense matching algorithms is still a difficult task to these small units, using simpler techniques involving binary imaging and criteriously chosen 3D information is a good way of surpassing those limitations. The possibility of combining stereoscopic data with the local variance filter results seems a promising way of more accurately

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classifying terrain, in particular water plane classification, and specific objects reducing the possibility of false matches. In the specific case of blob detection, redundancy achieved by simultaneous application of the Circular Hough Transform to the elected candidate will greatly reinforce the certainty of the detection. The inclusion of ultrasound sensors is a computationally and financially inexpensive way of rapidly detecting obstacles. In the future, surrounding the RPi Vehicle with several of these will create a cheap near field obstacle avoidance system.

REFERENCES

[1] Jan Erik Solem, "Programming Computer Vision with Python", 2nd ed. O'Reilly, 2013.
[2] Ricardo Neves, Anibal C. Matos, "Raspberry Pi based Stereo Vision for Small Size ASVs".
[3] T.Kowsari, S.S.Beauchemin, J.Cho, "Real-time Vehicle Detection and Tracking Using Stereo Vision and Multi-View AdaBoost",*IEEE Conference on Intelligent Transport Systems,Washington DC, USA, 5* Oct 2011.
[4] Peter Hillman, "White paper: Camera Calibration and Stereo Vision",27 Oct,2005.
[5] Ashutosh Saxena, Sung H.Chung, Andrew Y.Ng "3D Depth Reconstruction from a Single Still Image.
[6] Theo Gevers, Arnold W.M.Smeulders,"Color-based Object Recognition, *The Journal of the Pattern Recognition*, 4 Feb 1998.
[7] Donald B. Gennery, "A Stereo Vision System for an Autonomus Vehicle", *Unpublished*
[8] T.Surgailis, A.Valinevicius "Avoiding Forward Car Collision using StereoVision System" , *ISSN 1392-1215, VOL.18, NO.8,2012*
[9] Wikipedia "Single-board computer", Available: http://en.wikipedia.org/wiki/Single-board_computer
[10] Raspberry Pi GPIO Connections, Available: http://www.raspberrypi.org/pinout-for-gpio-connectors/
[11] Raspberry Pi Setup, Available: http://www.instructables.com/id/Ultimate-Raspberry-Pi-Configuration-Guide/

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