VISION BASED AUTONOMOUS SECURITY ROBOT

FUNCTIONAL REQUIREMENTS LIST
AND
PERFORMANCE SPECIFICATIONS

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INTRODUCTION

Computer vision is defined as making useful decisions about real physical objects and scenes based on sensed images [1]. Humans generally take the details of eyesight and the amount of information naturally derived from sight for granted. Machine vision incorporates artificially intelligent systems with image processing systems. The design of this project is to develop an autonomous vehicle with computer vision as its primary sensor for gaining information about its environment.

For most intelligent machines the capability of understanding the visual world is a prerequisite. Typically autonomous vehicles have many different types of sensors all operating simultaneously. This project will use a camera for navigation and obstacle avoidance as well as other tasks the robot must perform.

Applications for this type of technology are numerous. This particular design will be used as a security robot. At the most complex level this autonomous vehicle will receive a signal indicating that a disturbance in a particular room has been discovered. The Vision Based Autonomous Security Robot (VBASR) will then travel to that room and investigate, taking pictures of any culprits that it locates there. After the task has been completed it will return to its charging station.

PROJECT GOALS

- Primary
  - Locate and navigate down the center of a corridor.
  - Avoid obstacles in real time.
- Secondary
  - Map the hallway using images.
  - Recognize locations (rooms/offices) using pre-defined images of those locations, enabling point-to-point navigation into rooms.
  - Security Application: Locate and take a picture of an intruder sensed by motion detectors in a particular room. The environment for this goal is the second floor of Jobst Hall in the ECE wing.

SYSTEM BLOCK DIAGRAM

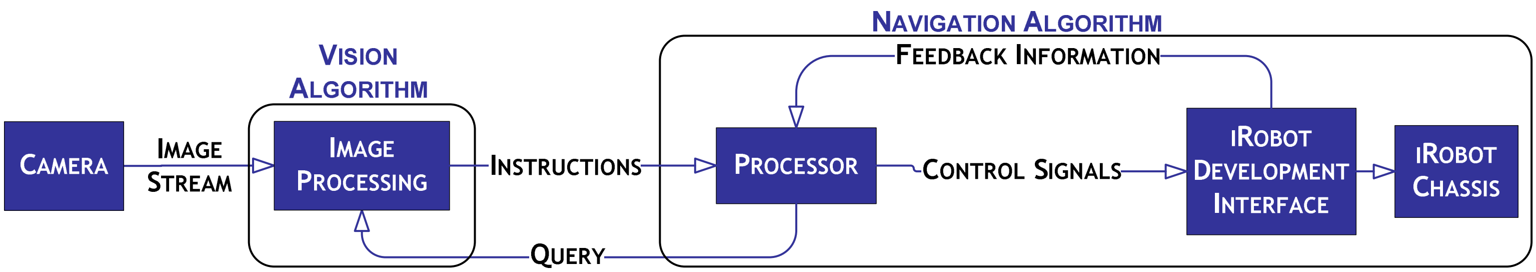

FIGURE 1 – COMPLETE SYSTEM BLOCK DIAGRAM

Software Flowchart

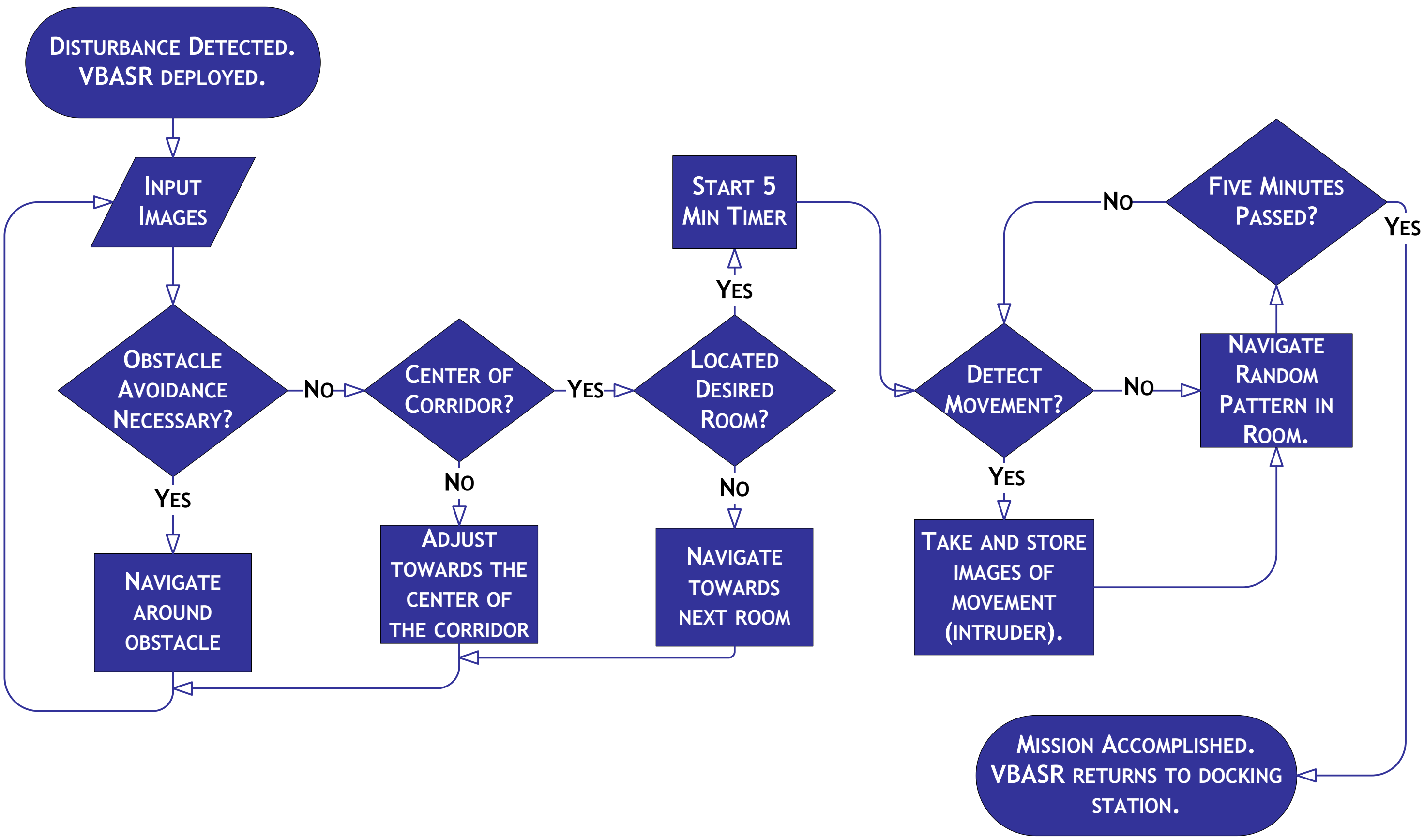

Figure 2 – Software Flowchart

Functional Requirements

Due to a focus on research and development, many of the specifications have yet to be determined. Generally robots follow the sense-plan-act process. For this application the camera does the sensing, microprocessor does the planning, and the robot platform reacts.

Overall, the specifications for the VBASR are behavioral rather than numeric. The specifications for the primary goals of this project include autonomous navigation, avoiding obstacles, and interacting with the environment in real time. Humans can interact effectively in real time and the robot is required to interact in a human environment so human reaction time was chosen as the upper limit for the software loop. This requires the main software loop to run at exactly (or less than) human reaction time which about 190ms for light stimuli and about 160ms for auditory stimuli [2].

A secondary goal of VBASR is using computer vision for the security application. Towards those ends, a database of images for each doorway and section of hallway must be created. During navigation, VBASR will compare its images to the image database to determine its current location. Moveable obstacles that may be left in a hallway must be filtered to enabling it to accurately compare the images.

To accomplish intruder detection, a network of cheaper sensors (motion detectors) will be monitored via an input signal from a laptop computer. When motion is detected after hours in a particular room, the laptop will send a signal to dispatch the VBASR to investigate.

VISION ALGORITHM – The vision algorithm provides the primary source of information to the microcontroller. Refer to Figure 1. If camera is equipped with the capabilities of on-board image processing, most of the vision algorithm will reside within the camera's processing board. After processing, it will then send the information into the microcontroller which will control the navigation of the VBASR. The camera will continually take images for the microcontroller to analyze. These images will be still shots, not streaming video. Upon completion of analysis of an image, the next image will be requested while the rest of the system operates as the first image dictates. If a laptop is determined necessary for the extra processing power then only a simple webcam may be required.

NAVIGATION ALGORITHM – Figure 2 shows the navigation algorithm. Refer to Figure 1 to see how the navigation algorithm (and the vision algorithm) makes up the entire system. The navigation algorithm controls VBASR by responding according to the conclusions of the vision algorithm. If a more advanced camera is used to do the image processing functions, the microcontroller's main function is to make the decisions and control the iRobot chassis. Another possibility is that a laptop computer (connected to the iRobot via Bluetooth) may be used for the processing power. Unfortunately, the addition of a laptop to the platform introduces several other undesirable challenges, increasing power consumption and creating mounting difficulties.

The iRobot Create command module consists of an electronic hardware interface and a software interface. The hardware consists of a 7 pin Mini-DIN connector and a DB-25 connector for connecting external hardware (e.g. a camera). The command module is powered by an Atmel AVR ATMega168 reprogrammable microcontroller. This microcontroller may be used as the microcontroller described above depending upon its capabilities. Using C or C++, personalized programs can be downloaded and implemented with this development interface.

To operate effectively in its environment, the VBASR should have a shorter reaction time than humans and must not drive at a rate that exceeds its ability to process images and make navigational decisions. Note that the VBASR will be sampling images as fast as the microprocessor can analyze them. Thus, the robot will have the fastest possible reaction time, ideally far greater than any human. In such a manner, the VBASR will quickly identify and avoid any sudden obstacles and also quickly identify any movement to photograph it.

Once the VBASR reaches and enters the specified room, it will run a random pattern looking for movement (intruders). If any movement is discovered within five minutes, incriminating photos will be taken and stored. After five minutes the VBASR will return to its docking station and await a new disturbance.

PERFORMANCE SPECIFICATIONS SUMMARY

- Vision Algorithm – Sampling and processing images in real time
- Navigation Algorithm – Main loop code must execute in 190ms max
  - Locate and navigate down the center of a corridor
  - Avoiding obstacles.
  - Cannot outdrive the vision algorithm
- Secondary
  - Map the hallway using images.
  - Recognize locations (rooms/offices) using pre-defined images of those locations, enabling point-to-point navigation into rooms.
  - Security Application: Locate and take a picture of an intruder sensed by motion detectors in a particular room.

REFERENCES

[1] Shapiro, Linda G., Linda G. Shapiro, and George Stockman. Computer Vision. Upper Saddle River: Prentice Hall, 2001. Print

[2] Kosinski, Robert J. "Literature Review on Reaction Time." Clemson University, Aug. 2009. Web. 10 Nov. 2009. <http://biae.clemson.edu/bpc/bp/Lab/110/reaction.htm>.