Suhani Jain
Project Advisor: Jennifer Hasler
AutoQuads

Analysis of Computer Vision and its Applications in Navigation Technology

Computer Vision is a technology that emerged in the late 20th century, but has really begun gaining steam as the technology surrounding it has advances and the applications of computer vision have become more apparent and ubiquitous. It is used in concurrence with robotics, vehicles, and other transportation mechanisms. Computer vision has become the basis for autonomous movement and detection, and allows for the use of artificial intelligence and machine learning to improve autonomous decision making within these devices.

To begin, computer vision is defined as "a field of study that seeks to develop techniques to help computers "see" and understand the content of digital images such as photographs and videos [1]." As a subfield of artificial intelligence and machine learning, computer vision attempts to dissect an image, through applying layers of filters and convolutions to get a more contextual understanding of the image. This technology is able to filter and image and determine what objects are present in the image, what are the key points for the image, where exactly are the objects in the image location. The difference between computer vision and image processing is that image processing is taking an image and creating a new image from it, whereas computer vision is taking an image and attempting to decipher the image and extract important information from it. For example, if two images of the same object from different angles was processed via computer vision, the algorithm would be able to determine what key points exist for both images and then match them together in an attempt to determine if the images were of the same object or not [2].

One of the practical applications of computer vision is the cost reduction, due to the lack of sensors and high tech equipment needed. Only a camera is needed, and egomotion refers to estimating a camera's motion relative to a rigid scene, which is used in applications such as moving vehicles. The benefits of using egomotion are getting a wholistic scope of the environment surrounding and capturing sequences of images to produce a 3D model. When conducting distance detection, two cameras are used to obtain different perspectives, and compared to determine depth and distance. The applications of this technology are abundant with regards to navigation, within vehicles and devices.

Unmanned underwater vehicle navigation is an area where computer vision has become a new solution for overcoming difficulties that are evident with underwater detection. Some of this challenges include "the rapid attenuation of acoustic and electromagnetic radiation in water restricts the range of acoustic and optical sensors and also limits communication bandwidth [3]. Other challenges are the ambient pressure underwater, the changing underwater landscape due to the movement of animals and water. Many of these challenges can be overcome using computer vision, as its hardware is lightweight, flexible, and motion estimation can be used to determine the differences between changing objects/landscapes. Bathymetric LiDAR is commonly used for underwater detection, as laser radar pulses are sent through the water surface and reflect off the bottom of the ocean floor, and are returned to a sensor which determines the distance and topography of the space. The problem with LiDAR is it is very complicated to determine what exactly is being detected, is it an animal, a rock, or the ocean floor? With computer vision, images of exact objects are extracted and used to determine what LiDAR can and more. Using computer vision can allow for unmanned vehicles to move underwater, as they can constantly detect objects and their relevant distances, as well as map the space around it.

One of the most prevalent uses of computer vision is in autonomous vehicles [4]. Used in conjunction with LiDAR and IR sensing, computer vision can be used to help map entire spaces around vehicles, and assist in algorithmic decision making. Computer vision implements edge detection, which is one of the primary ways to determine/detect and object. As professor Shetty from UIUC mentions in his lectures on computer vision and its applications with autonomous robots [5], matching images comes from 3 main criteria: epipolar constraints, disparity, and scale/orientation. Matching key points in images is essential in storing information about a setting, and then using this information to track changes that occur in the setting, as well as changes that occur as a result of the vehicle/device moving.

To some, autonomous navigation seems like a concept that has little impact on day to day life for normal people. Contrary to this belief, the applications of computer vision are used to improve menial tasks as well. Research on computer vision navigation with regards to helping a customer navigate to a selected product in a retail store are prevalent as well [6]. Using a simple smart phone camera and being able to instantly detect a desired object, as well as compare it with other brands as well. Additionally, being able to navigate efficiently through a store and determine the shortest possible route to get all the desired items is another application which heavily impacts consumers, and is a low cost solution to a problem nearly everyone has.

The power of computer vision is very evident, and its implementations are so low cost that it is being widely adopted by technologists and companies everywhere. As the impact of artificial intelligence and machine learning grows, along with it, computer vision is gaining steam as the new, effective way to process images and detect. Since the effectiveness and primary dependency of computer vision is the quality of the image, the main limiting factor is getting high quality cameras to be able to capture high resolution photos for the vision algorithms to use to processes the image accordingly. The confidences of these determinations are calculate-able, and with greater varying images comes lower confidences. As the technology is adapted and manipulated, its accuracy improves.The benefits, however, are the increase in ubiquitous usage, and ability to better interpret surrounding and images, especially in a three dimensional space.

Website

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Lectures

[5] Sanketh Shetty, "COMPUTER VISION FOR ROBOT NAVIGATION", Febr 16, 2016, Computer Vision and Robotics Laboratory University of Illinois Urbana-Champaign, http://dhoiem.cs.illinois.edu/courses/cs598_spring09/slides/cs598_robots_sanketh.pdf