National University
Of Computer and Emerging Sciences

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Goal

The goals of the computer and information sciences department are to prepare students for graduate training in some specialized area of computer science, to prepare students for jobs in industry, business or government, and to provide support courses for students in engineering,

Objective

Upon successful completion of a major in computer and information sciences, students will be able to:

1. Demonstrate proficiency in problem-solving techniques using the computer
2. Demonstrate proficiency in at least two high-level programming languages and two operating systems
3. Demonstrate proficiency in the analysis of complex problems and the synthesis of solutions to those problems
4. Demonstrate comprehension of modern software engineering principles
5. Demonstrate a breadth and depth of knowledge in the discipline of computer science

Motivation

The goal of this project is to develop and validate a new measure of student motivation that can be used to understand the impact of interventions on student achievement and students' interest in STEM disciplines. This project will help link teaching practices to increases in student motivation and persistence in STEM fields.

Existing motivation-based evaluation measures have a variety of limitations for routine, widespread use. In contrast, the measure being developed in this project is designed to be rapid and practical (low response burden), intuitive, grounded in the social-cognitive qframework of Expectancy-Value motivation, and not specific to a part..

TOPIC: COMPUTER VISION

Computer vision is an interdisciplinary scientific field that deals with how computers can be made to gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do.

Computer vision tasks include methods for acquiring, processing, analyzing and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or symbolic information, e.g. in the forms of decisions. Understanding in this context means the transformation of visual images (the input of the retina) into descriptions of the world that can interface with other thought processes and elicit appropriate action. This image understanding can be seen as the disentangling of symbolic information from image data using models constructed with the aid of geometry, physics, statistics, and learning theory.

As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models for the construction of computer vision systems.

Definition

Computer vision is an interdisciplinary field that deals with how computers can be made to gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do. "Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding. As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models for the construction of computer vision systems.

HISTORY

In the late 1960s, computer vision began at universities that were pioneering artificial intelligence. It was meant to mimic the human visual system, as a stepping stone to endowing robots with intelligent behavior. In 1966, it was believed that this could be achieved through a summer project, by attaching a camera to a computer and having it "describe what it saw".

What distinguished computer vision from the prevalent field of digital image processing at that time was a desire to extract three-dimensional structure from images with the goal of achieving full scene understanding. Studies in the 1970s formed the early foundations for many of the computer vision algorithms that exist today, including extraction of edges from images, labeling of lines, non-polyhedral and polyhedral modeling, representation of objects as interconnections of smaller structures, optical flow, and motion estimation.

The next decade saw studies based on more rigorous mathematical analysis and quantitative aspects of computer vision. These include the concept of scale-space, the inference of shape from various cues such as shading, texture and focus, and contour models known as snakes. Researchers also realized that many of these mathematical concepts could be treated within the same optimization framework as regularization and Markov random fields. By the 1990s, some of the previous research topics became more active than the others. Research in projective 3-D reconstructions led to better understanding of camera calibration. With the advent of optimization methods for camera calibration, it was realized that a lot of the ideas were already explored in bundle adjustment theory from the field of photogrammetry. This led to methods for sparse 3-D reconstructions of scenes from multiple images. Progress was made on the dense stereo correspondence problem and further multi-view stereo techniques. At the same time, variations of graph cut were used to solve image segmentation. This decade also marked the first time statistical learning techniques were used in practice to recognize faces in images (see Eigenface). Toward the end of the 1990s, a significant change came about with the increased interaction between the fields of computer graphics and computer vision. This included image-based rendering, image morphing, view interpolation, panoramic image stitching and early light-field rendering.

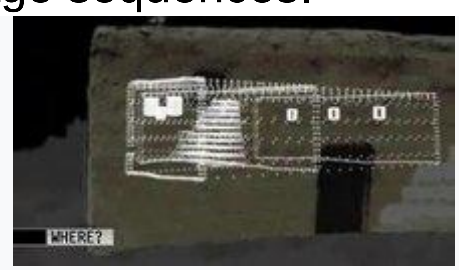
Recent work has seen the resurgence of feature-based methods, used in conjunction with machine learning techniques and complex optimization frameworks. The advancement of Deep Learning techniques has brought further life to the field of computer vision. The accuracy of deep learning algorithms on several benchmark computer vision data sets for tasks ranging from classification, segmentation and optical flow has surpassed prior methods.

APPLICATIONS

Applications range from tasks such as industrial machine vision systems which, say, inspect bottles speeding by on a production line, to research into artificial intelligence and computers or robots that can comprehend the world around them. The computer vision and machine vision fields have significant overlap. Computer vision covers the core technology of automated image analysis which is used in many fields. Machine vision usually refers to a process of combining automated image analysis with other methods and technologies to provide automated inspection and robot guidance in industrial applications. In many computer-vision applications, the computers are pre-programmed to solve a particular task, but methods based on learning are now becoming increasingly common. Examples of applications of computer vision include systems for:

Learning 3D shapes has been a challenging task in computer vision. Recent advances in deep learning has enabled researchers to build models that are able to generate and reconstruct 3D shapes from single or multi-view depth maps or silhouettes seamlessly and efficiently

- Automatic inspection, *e.g.*, in manufacturing applications;
- Assisting humans in identification tasks, e.g., a species identification system;
- Controlling processes, *e..g*, an industrial robot;
- Detecting events, *e.g.*, for visual surveillance or people counting;
- Interaction, *e.g.*, as the input to a device for computer-human interaction;
- Modeling objects or environments, *e.g.*, medical image analysis or topographical modeling;
- Navigation, *e.g.*, by an autonomous vehicle or mobile robot; and
- Organizing information, *e.g.*, for indexing databases of images and image sequences.



DARPA's Visual Media Reasoning concept

One of the most prominent application fields is medical computer vision, or medical image processing, characterized by the extraction of information from image data to diagnose a patient. An example of this is detection of tumors, arteriosclerosis or other malign changes; measurements of organ dimensions, blood flow, etc. are another example. It also supports medical research by providing new information: *e.g.*, about the structure of the brain, or about the quality of medical treatments. Applications of computer vision in the medical area also includes enhancement of images interpreted by humans—ultrasonic images or X-ray images for example—to reduce the influence of noise.

A second application area in computer vision is in industry, sometimes called machine vision, where information is extracted for the purpose of supporting a manufacturing process. One example is quality control where details or final products are being automatically inspected in order to find defects. Another example is measurement of position and orientation of details to be picked up by a robot arm. Machine vision is also heavily used in agricultural process to remove undesirable food stuff from bulk material, a process called optical sorting.

Military applications are probably one of the largest areas for computer vision. The obvious examples are detection of enemy soldiers or vehicles and missile guidance. More advanced systems for missile guidance send the missile to an area rather than a specific target, and target selection is made when the missile reaches the area based on locally acquired image data. Modern military concepts, such as "battlefield awareness", imply that various sensors, including image sensors, provide a rich set of information about a combat scene which can be used to support strategic decisions. In this case, automatic processing of the data is used to reduce complexity and to fuse information from multiple sensors to increase reliability.

One of the newer application areas is autonomous vehicles, which include submersibles, land-based vehicles (small robots with wheels, cars or trucks), aerial vehicles, and unmanned aerial vehicles (UAV). The level of autonomy ranges from fully autonomous (unmanned) vehicles to vehicles where computer-vision-based systems support a driver or a pilot in various situations. Fully autonomous vehicles typically use computer vision for navigation, *e.g.* for knowing where it is, or for producing a map of its environment (SLAM) and for detecting obstacles. It can also be used for detecting certain task specific events, *e.g.*, a UAV looking for forest fires. Examples of supporting systems are obstacle warning systems in cars, and systems for autonomous landing of aircraft. Several car manufacturers have demonstrated systems for autonomous driving of cars, but this technology has still not reached a level where it can be put on the market. There are ample examples of military autonomous vehicles ranging from advanced missiles to UAVs for recon missions or missile guidance. Space exploration is already being made with autonomous vehicles using computer vision, *e.g.*, NASA's Mars Exploration Rover and ESA's ExoMars Rover.

Other application areas include:

- Support of visual effects creation for cinema and broadcast, *e.g.*, camera tracking .
- Surveillance.

- Artist's concept of a Mars Exploration Rover, an example of an unmanned land-based vehicle. Notice the stereo cameras mounted on top of the rover.