COMPUTER VISION

Computer vision is the science and technology of machines that see.

As a scientific discipline, computer vision is concerned with the theory and technology for building artificial systems that obtain information from images. The image data can take many forms, such as a video sequence, views from multiple cameras, or multi-dimensional data from a medical scanner.

As a technological discipline, computer vision seeks to apply the theories and models of computer vision to the construction of computer vision systems. Examples of applications of computer vision systems include systems for

1. Controlling processes (e.g. an industrial robot or an autonomous vehicle).
2. Detecting events (e.g. for visual surveillance or people counting)
3. Organizing information (e.g. for indexing databases of images and image sequences),
4. Modeling objects or environments (e.g. industrial inspection, medical image analysis or topographical modeling),
5. Interaction (e.g. as the input to a device for computer-human interaction).

Computer vision can also be described as a complement (but not necessarily the opposite) of biological vision. In biological vision, the visual perception of humans and various animals are studied, resulting in models of how these systems operate in terms of physiological processes. Computer vision, on the other hand, studies and describes artificial vision system that are implemented in software and/or hardware. Interdisciplinary exchange between biological and computer vision has proven increasingly fruitful for both fields.

Sub-domains of computer vision include scene reconstruction, event detection, tracking, object recognition, learning, indexing, ego-motion and image restoration.

State of the art

The field of computer vision can be characterized as immature and diverse. Even though earlier work exists, it was not until the late 1970s that a more focused study of the field started when computers could manage the processing of large data sets such as images. However, these studies usually originated from various other fields, and consequently there is no standard formulation of "the computer vision problem". Also, and to an even larger extent, there is no standard formulation of how computer vision problems should be solved. Instead, there exists an abundance of methods for solving various well-defined computer vision tasks, where the methods often are very task specific and seldom can be generalized over a wide range of applications. Many of the methods and applications are still in the state of basic research, but

more and more methods have found their way into commercial products, where they often constitute a part of a larger system which can solve complex tasks (e.g., in the area of medical images, or quality control and measurements in industrial processes). In most practical computer vision applications, the computers are pre-programmed to solve a particular task, but methods based on learning are now becoming increasingly common.

A significant part of artificial intelligence deals with autonomous planning or deliberation for system which can perform mechanical actions such as moving a robot through some environment. This type of processing typically needs input data provided by a computer vision system, acting as a vision sensor and providing high-level information about the environment and the robot. Other parts which sometimes are described as belonging to artificial intelligence and which are used in relation to computer vision is pattern recognition and learning techniques. As a consequence, computer vision is sometimes seen as a part of the artificial intelligence field or the computer science field in general.

Physics is another field that is strongly related to computer vision. A significant part of computer vision deals with methods which require a thorough understanding of the process in which electromagnetic radiation, typically in the visible or the infra-red range, is reflected by the surfaces of objects and finally is measured by the image sensor to produce the image data. This process is based on optics and solid state physics. More sophisticated image sensors even require quantum mechanics to provide a complete comprehension of the image formation process. Also, various measurement problems in physics can be addressed using computer vision, for example related to motion in fluids. Consequently, computer vision can also be seen as an extension of physics.

A third field which plays an important role is neurobiology, specifically the study of the biological vision system. Over the last century, there has been an extensive study of eyes, neurons, and the brain structures devoted to processing of visual stimuli in both humans and various animals. This has led to a coarse, yet complicated, description of how "real" vision systems operate in order to solve certain vision related tasks. These results have led to a subfield within computer vision where artificial systems are designed to mimic the processing and behaviour of biological systems, at different levels of complexity. Also, some of the learning-based methods developed within computer vision have their background in biology.

Yet another field related to computer vision is signal processing. Many methods for processing of one-variable signals, typically temporal signals, can be extended in a natural way to processing of two-variable signals or multi-variable signals in computer vision. However, because of the specific nature of images there are many methods developed within computer vision which have no counterpart in the processing of one-variable signals. A distinct character of these methods is the fact that they are non-linear which, together with the multi-dimensionality of the signal, defines a subfield in signal processing as a part of computer vision.

Beside the above mentioned views on computer vision, many of the related research topics can also be studied from a purely mathematical point of view. For example, many methods in computer vision are based on statistics, optimization or geometry. Finally, a significant part of the field is devoted to the implementation aspect of computer vision; how existing methods can be realized in various combinations of software and hardware, or how these methods can be modified in order to gain processing speed without losing too much performance.

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