

# Computer vision

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*This is a report on the topic "Computer Vision". Its analysis examines issues related to the recognition of objects and the determination of their spatial organization. In order to recognize these objects that enter the image, it is necessary to have a system (biological or technical) and to train it. The computer vision system is a set of specialized devices for forming the image of the environment.*

*Keywords – artificial intelligence, computer vision system, electromagnetic spectrum, eyesight, electromagnetic spectrum.*

*Компютърно зрение (Юлиана Р. Светлозарова, Илонка Д. Вутова). Докладът представя разработка на тема "Компютърно зрение". В анализа му са засегнати въпроси, свързани с разпознаването на обектите и определянето на пространствената им организация. За да се разпознаят тези обекти, които влизат в изображението е необходимо да има система (биологична или техническа) и тя да бъде обучена. Системата за компютърно зрение е съвкупност от специализирани устройства за формиране на изображението за околната среда.*

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## Introduction

Artificial intelligence (AI) is one of the latest fields in computer science and is increasingly entering practical engineering and technology. It is an interdisciplinary field, which foundations and terminology can be drawn from various theories and concepts in philosophy, mathematics, linguistics, economics, psychology, and sociology. However, it is extremely difficult to formulate a definition that covers and incorporates all aspects of the field. Computer vision is a scientific area of computer science closely related to artificial intelligence, as the computer must interpret what it sees and then perform appropriate analysis and/or take action accordingly.

## Methodology

In order to develop the topic more comprehensively, the materials provided by my supervisor have been utilized. These materials are related to the project "Support for the Dual System of Education" (PDSE), "Computer Vision and Neural Networks" by Gocho Gochev, and "Artificial Intelligence - Problem Solving through Search" by the author collective of Izkustva Publishing. Additionally, internet research has been conducted to gather relevant information, and appropriate data has been selected and structured according to the topic.

In recent years, we have witnessed a growing interest in artificial intelligence. Computer vision is a step towards enabling computers to perform human

tasks, aiming to enhance efficiency and reduce errors. This multidisciplinary approach allows computers to transform images into meaningful data and interpret the relationships between different pieces of information [1].

## Physical foundations of Computer Vision

The visible light perceived through human vision consists of electromagnetic oscillations with wavelengths ranging from 400 to 700 nm (1 nanometer =  $10^{-9}$  m). Vision can be seen as the perception of the reflected (or emitted) electromagnetic energy from objects in the surrounding environment, its analysis for extracting information about the environment, and the recognition of objects within it. Computer vision methods can be applied to any region of the electromagnetic spectrum (Fig.1) where an image of the observed surrounding environment is obtained. Computer vision represents a form of remote sensing, i.e., measurement and analysis from a distance [1].

An interesting definition for an AI system was proposed by Donald Michie, the director of the University of Edinburgh.

**Definition 1:** The system is considered to have artificial intelligence if there is a positive answer to the following five questions:

1) Does the system form a model of the environment?

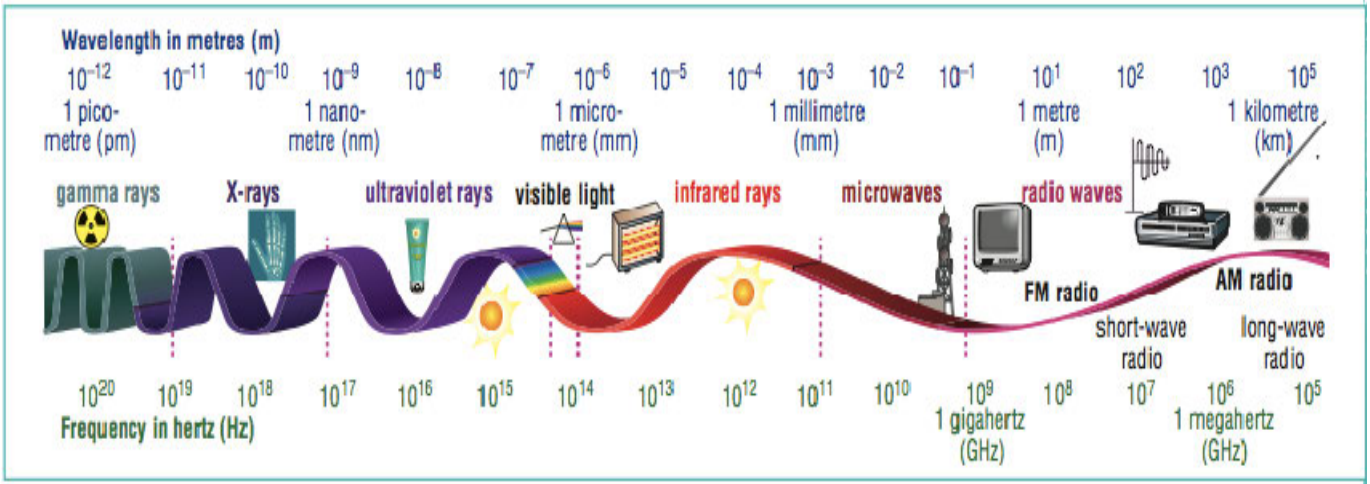


Fig.1. The electromagnetic spectrum and its regions [3].

2) Does the system use the model of the environment to generate an action plan executed in that environment?

3) Does the action plan involve analyzing alternative possibilities?

4) Can the system modify the plan if its execution leads to unpredictable states in the environment?

5) Can the system use past experience for intuitive expansion and correction of the model of the environment?

This definition implies purposeful behavior of the system based on knowledge about the environment.

**Definition 2:** The surrounding environment is understood as the collection of objects within the field of view of the video-capturing apparatus of the system.

The primary means of obtaining information about the surrounding environment is visual perception. From the perspective of artificial intelligence, the task of a computer vision system (CVS) is to perceive visual information about the environment, construct a description of that environment, and analyze that description in order to extract specific information. Classifications of CVS and their usage can be divided into CVS for analyzing scenes containing two-dimensional (flat) objects and scenes containing three-dimensional objects (Fig.2). Three-dimensional scenes involve volumetric objects, such as details with clearly defined three-dimensionality. In order to define the structure of a CVS, it is necessary to determine what eyesight entails. This is done based on definitions.

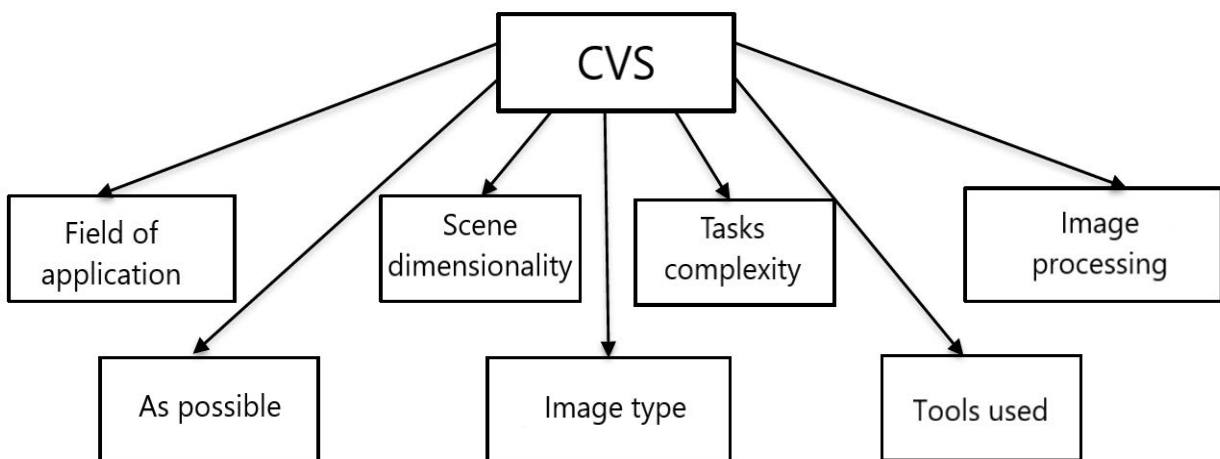


Fig.2. Classifications of CVS [1].

**Definition 3:** Vision is the process of determining, through an image, what exactly is present in the surrounding environment and where it is located.

The composition of the surrounding environment is reduced to an image on the retinal field of the eye or the input field of a technical video sensor. During the analysis of the image, decomposition into individual objects is performed, followed by object recognition and determination of their spatial relationships. In order to carry out object recognition and determine their spatial organization, the system (biological or technical) must possess the ability to internally represent and store information from the image in a specific way, as well as perform the necessary transformations and computations on this information. To achieve object recognition of the entities present in the image, the system needs to be pre-trained. Therefore, important tasks for vision include:

- Image formation
- Presenting and storing information in a specific way
- System training
- Recognition of objects present in the image

**Definition 4:** Computer vision refers to the perception of visual information about the surrounding environment using video sensors, constructing a description of the scene based on its image, representing the scene description in the computer's memory, and interpreting it to recognize objects based on criteria obtained during training. It

involves building a model of the environment [1.]

Therefore, a computer vision system can be defined as a set of specialized devices for capturing images of the surrounding environment, a computer system for representing and storing the information from the images, and corresponding software. The software is developed based on methods and algorithms for analyzing, training, and recognizing objects from the visual scene and constructing a model of the environment [2].

### **Applications of computer vision technologies.**

#### ***Face recognition.***

Perhaps the most popular and controversial use of computer vision technology is face recognition [4]. The applications are almost limitless and range from personal use to public safety measures (Fig. 3).

#### ***Traffic, Driving, and the Automotive Industry.***

Computer vision has changed the way we drive and handle traffic. It opens doors to adaptive technologies that enhance driving and helps cities reduce congestion by addressing problematic streets.

#### ***Healthcare Industry.***

Healthcare remains at the forefront of most technological advancements. It is not surprising that the healthcare industry has embraced computer vision for cancer detection, cell classification, for disease identification, and more recently, COVID diagnoses (Fig. 4).



*Fig.3. Face recognition [5].*



Fig.4. Healthcare Industry [6].

### **Support for Retail Trade**

Software automation for computer vision supports retail stores by tracking customers to monitor foot traffic in the stores.

### **Agricultural Applications**

Farmers with huge property can optimize their work using computer vision software that tracks livestock and crops.

### **Conclusion**

Areas with high transmission (and corresponding reflection) of electromagnetic energy are the visible part of infrared and microwave regions. Human vision occurs in the visible part of the electromagnetic spectrum. This range is also fundamental for computer vision systems as they attempt to algorithmically mimic human vision. Taking it a step further, the process enables computers to interpret a given scene and formulate an appropriate response. Embracing computer vision tools as part of software testing automation is another step in the technological revolution. It plays a crucial role in many daily activities and aims to enhance our everyday tasks by reducing errors, improving quality, and increasing profitability.

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