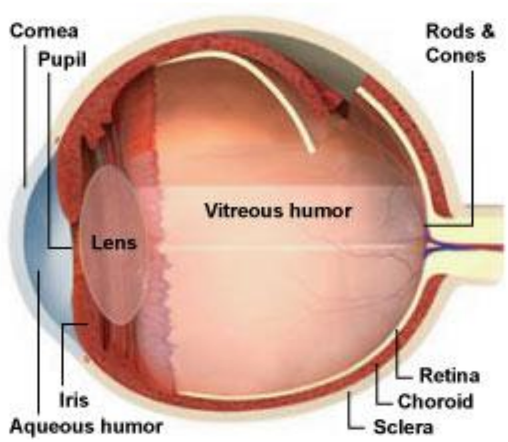
UNIT – IV (Visual Perception)

Visual perception is the ability to interpret the surrounding environment by processing information that is contained in visible light. The resulting perception is also known as eyesight, sight, or vision.

Visual perception is the ability to see and interpret (analyze and give meaning to) the visual information that surrounds us. The process of "taking in" one's environment is referred to as perception. If perception is inaccurate, incorrect or altered in any way - problems with reading, spelling, handwriting, math and comprehension occur. Visual perceptual skills involve the ability to organize and interpret the information that is seen and give it meaning. The importance of visual perceptual skills in academic success is agreed upon by many, acknowledging reading would not be possible without adequate visual perception. Visual perceptual processing impacts the ability to learn. Without accurate visual perceptual processing, a student would have difficulty learning to read, give or follow directions, copy from the whiteboard, visualize objects or past experiences, have good eye-hand coordination, integrate visual information with other senses to do things like ride a bike, play catch, shoot baskets when playing basketball, or hear a sound and visualize where it is coming from (like the siren on a police car).

Visual perceptual skills include several key component areas: Visual Discrimination: The ability to notice detail differences such as shape, size, color, or other dimensional aspects. Form Constancy (Form Discrimination): The ability to perceive positional aspect differences and recognize objects when they are in a different orientation or format. Figure Ground (Foreground-Background Differentiation): The ability to focus on a selected target and screen out or ignore irrelevant images. Spatial Relations: The ability to recognize the positioning of objects in space. Visual Closure: The ability to recognize an object, letter or number without seeing all of the object. Visual Sequencing: The ability to see objects in a particular sequential order. Visual Memory: The ability to remember forms (letters) and sequences of forms (words) and recognize them quickly when seen again.

Biology of Vision:



Structure of the eye:

The cornea is a transparent structure found in the very front of the eye that helps to focus incoming light. Situated behind the pupil is a colorless, transparent structure called the crystalline lens. A clear fluid called the aqueous humor fills the space between the cornea and the iris. The cornea focuses most of the light, then it passes through the lens, which continues to focus the light, Behind the cornea is a colored, ring-shaped membrane called the iris. The iris has an adjustable circular opening called the pupil, which can expand or contract to control the amount of light entering the eye. Ciliary muscles surround the lens. The muscles hold the lens in place but they also play an important role in vision. When the muscles relax, they pull on and flatten the lens, allowing the eye to see objects that are far away. To see closer objects clearly, the ciliary muscle must contract in order to thicken the lens. The interior chamber of the eyeball is filled with a jelly-like tissue called the vitreous humor. After passing through the lens, light must travel through this humor before striking the sensitive layer of cells called the retina. Retina is the innermost of three tissue layers that make up the eye. The outermost layer, called the sclera, is what gives most of the eyeball its white color. The cornea is also a part of the outer layer. The middle layer between the retina and sclera is called the choroid. The choroid contains blood vessels that supply the retina with nutrients and oxygen and remove its waste products. Embedded in the retina are millions of light sensitive cells, which come in two main varieties: rods and cones. Rods are used for monochrome vision in poor light, while cones are used for color and for the detection of fine detail. Cones are packed into a part of the retina directly behind the retina called the fovea, which is responsible for sharp central vision. When light strikes either the rods or the cones of the retina, it's converted into an electric signal that is relayed to the brain via the optic nerve. The brain then translates the electrical signals into the images a person sees.

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 tasks include methods for acquiring, processing, analyzing and understanding digital images, and in general, deal with the 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. Sub-domains of computer vision include scene reconstruction, event detection, video tracking, object recognition, object pose estimation, learning, indexing, motion estimation, and image restoration. Areas of artificial intelligence deal with autonomous planning or deliberation for robotical systems to navigate through an environment. A detailed understanding of these environments is required to navigate through them. Information about the environment could be provided by a computer vision system, acting as a vision sensor and providing high-level information about the environment and the robot.

Artificial intelligence and computer vision share other topics such as pattern recognition and learning techniques. Consequently, computer vision is sometimes seen as a part of the artificial intelligence field or the computer science field in general.

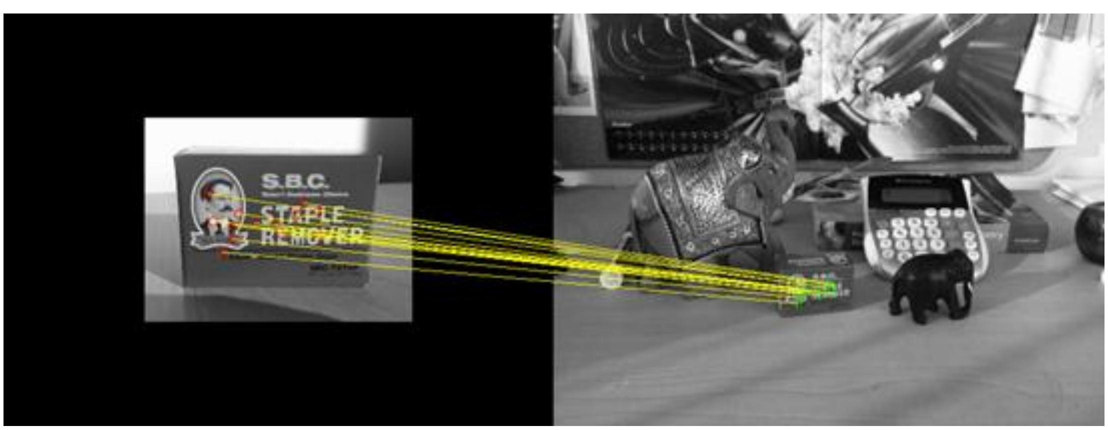
The fields most closely related to computer vision are image processing, image analysis and machine vision. There is a significant overlap in the range of techniques and applications that these covers. This implies that the basic techniques that are used and developed in these fields are more or less identical, something which can be interpreted as there is only one field with different names. On the other hand, it appears to be necessary for research groups, scientific journals, conferences and companies to present or market themselves as belonging specifically to one of these fields and, hence, various characterizations which distinguish each of the fields from the others have been presented. Computer vision is, in some ways, the inverse of computer graphics. While computer graphics produces image data from 3D models, computer vision often produces 3D models from image data. There is also a trend towards a combination of the two disciplines, e.g., as explored in augmented reality. The following characterizations appear relevant but should not be taken as universally accepted: Image processing and image analysis tend to focus on 2D images, how to transform one image to another, e.g., by pixel-wise operations such as contrast enhancement, local operations such as edge extraction or noise removal, or geometrical transformations such as rotating the image. This characterization implies that image processing/analysis neither require assumptions nor produce interpretations about the image content. Computer vision includes 3D analysis from 2D images. This analyzes the 3D scene projected onto one or several images, e.g., how to reconstruct structure or other information about the 3D scene from one or several images. Computer vision often relies on more or less complex assumptions about the scene depicted in an image. Machine vision is the process of applying a range of technologies & methods to provide imaging-based automatic inspection, process control and robot guidance in industrial applications. Machine vision tends to focus on applications, mainly in manufacturing, e.g., vision based autonomous robots and systems for vision based inspection or measurement. This implies that image sensor technologies and control theory often are integrated with the processing of image data to control a robot and that real-time processing is emphasised by means of efficient implementations in hardware and software. It also implies that the external conditions such as lighting can be and are often more controlled in machine vision than they are in general computer vision, which can enable the use of different algorithms. There is also a field called imaging which primarily focus on the process of producing images, but sometimes also deals with processing and analysis of images. For example, medical imaging includes substantial work on the analysis of image data in medical applications. Finally, pattern recognition is a field which uses various methods to extract information from signals in general, mainly based on statistical approaches and artificial neural networks. A significant part of this field is devoted to applying these methods to image data. Photogrammetry also overlaps with computer vision, e.g., stereophotogrammetry vs. stereo computer vision.

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

Object recognition methods in computer vision: It is the technology in the field of computer vision for finding and identifying objects in an image or video sequence. Humans recognize a multitude of objects in images with little effort, despite the fact that the image of the objects may vary somewhat in different view points, in many different sizes and scales or even when they are translated or rotated. Objects can even be recognized when they are partially obstructed from view. This task is still a challenge for computer vision systems. Many approaches to the task have been implemented over multiple decades.

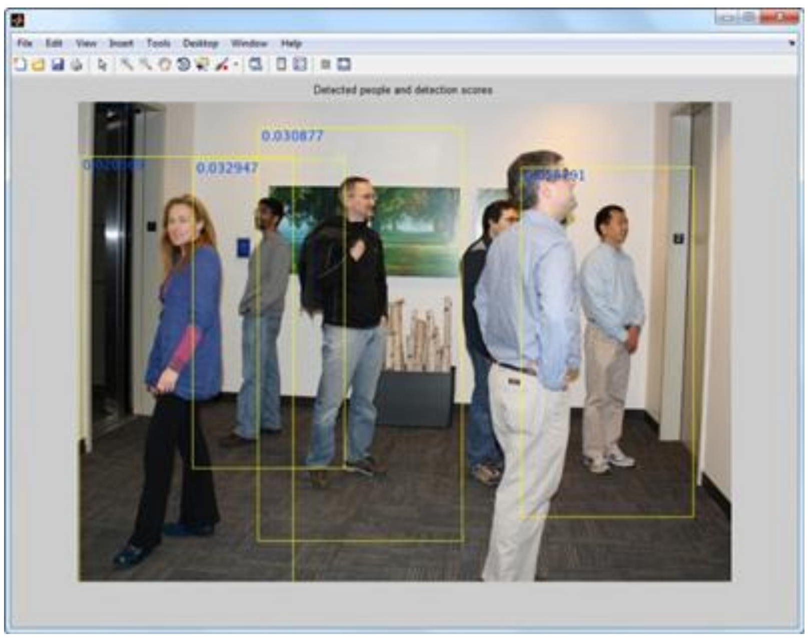
Object recognition algorithms rely on matching, learning, or pattern recognition algorithms using appearance-based or feature-based techniques. Common techniques include edges, gradients, Histogram of Oriented Gradients (HOG), Haar wavelets, and linear binary patterns. Object recognition is useful in applications such as video stabilization, automated vehicle parking systems, and cell counting in bioimaging. The objects can be can recognized using a variety of models, including: Extracted features and boosted learning algorithms Bag-of-words models with features such as SURF and MSER Gradient-based and derivative-based matching approaches Viola-Jones algorithm Template matching Image segmentation and blob analysis

Object detection in computer vision: Itis the process of finding instances of real-world objects such as faces, bicycles, and buildings in images or videos. Object detection algorithms typically use extracted features and learning algorithms to recognize instances of an object category. It is commonly used in applications such as image retrieval, security, surveillance, and automated vehicle parking systems. The objects can be detected using a variety of models, including: Feature-based object detection Detecting a reference object (left) in a cluttered scene (right) using feature extraction and matching.



Detecting a reference object (left) in a cluttered scene (right) using feature extraction and matching. RANSAC is used to estimate the location of the object in the test image.

Viola-Jones object detection Face detection (left) and stop sign detection (right) using the Viola-Jones Object Detector. Face detection (left) and stop sign detection (right) using the Viola-Jones Object Detector. SVM classification with histograms of oriented gradients (HOG) features Human detection using pretrained SVM with HOG features.



Human detection using pretrained SVM with HOG features.

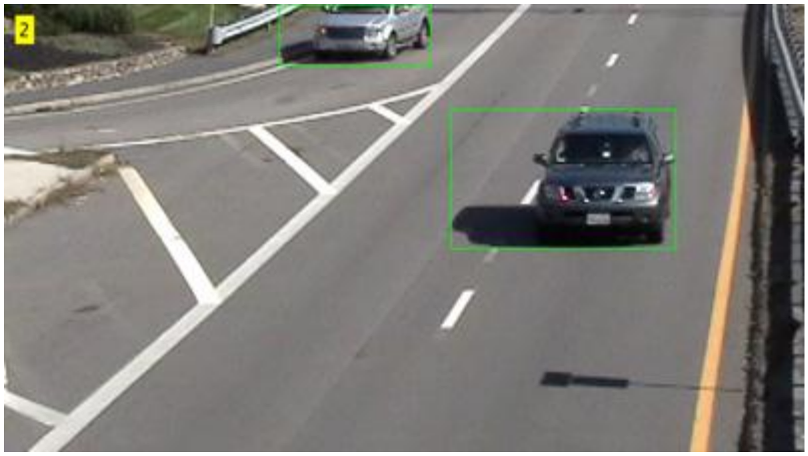


Image segmentation and blob analysis Moving cars are detected using blob analysis. Moving cars are detected using blob analysis. Image segmented using background subtraction. Image segmented using background subtraction.

The moving pixels (foreground) detected from the video frame above are shown in white. Other methods for detecting objects with computer vision include using gradient-based, derivative-based, and template matching approaches. These features of image processing could be done MATLAB Mathworks software.

Factory Vision Systems:

Machine vision systems can perform repetitive tasks faster, more accurately, and with greater consistency over time than humans. They can reduce labor costs, increase production yields, and eliminate costly errors associated with incomplete or incorrect assembly. They can help automatically identify and correct manufacturing problems on-line by forming part of the factory control network. The net result is greater productivity and improved customer satisfaction through the consistent delivery of quality products. Implementing a cost-effective machine vision system, however, is not a casual task. The selection of components and system programming must accurately reflect the application's requirements. In addition, selection decisions need to consider more than the initial component costs. Factors such as the time required for system development, installation, and integration with the factory system, the operator training (and retraining) costs, project management, maintenance, and software upgrades and modification, all contribute to the total cost of ownership for the system and should be evaluated before investing in a specific system design.

Inspection requires an ability to examine objects in detail and evaluate the image to make pass/fail decisions. Assembly, on the other hand, requires the ability to scan an image to locate reference marks (called fiducials) and then use those marks to determine placement and orientation of parts. A machine vision system designed for the one task may not be well suited to the other.

The vision system's lighting, camera and lens must perform adequately. Factors such as the smallest object or defect to detect, the texture of the parts, the measurement accuracy needed, the image size (field of view), speed of image capture and processing, and the need for color all affect lighting, camera and lens choices.

Some cameras are better for stationary views while others are more suitable for viewing moving objects. Temperature, humidity, vibration, and the like can impose needs for protecting the vision system components. The physical space available for installing the system can restrict camera and lens choices. If the expertise to configure the system is not available in-house, the user must depend on third-party support to make changes and correct errors in the vision system's programming. If the system needs periodic changes, such as to inspect a new product line or to interface with new production equipment, the question of programming becomes particularly important. A system that has been set up for a single task so that the system integrator needs to reconfigure it for new settings can result in production systems being shut down for extended periods while alterations are underway. A system set up with enough flexibility to allow factory personnel to make such adjustments may cost more to create, but will save production time later.

A vision system that only activates a solenoid to eject failed parts from a production line is considerably easier to implement than one that also reports results to a quality control network or that controls the operation of production equipment based on inspection results. Similarly, a system that must interact with a human operator has different needs than one that interfaces only to other machines.

Machine vision systems in factory automation seldom operate in a stand-alone mode. Instead, they send information to other parts of the factory enterprise for a variety of purposes. Quality traceability, for instance, requires that the vision system either log or report inspection results to the enterprise. Highly controlled operations, such as pharmaceutical manufacturing, may also require the logging of access to and changes made in the vision system, sending such data to secure storage on the company network.

The extent to which human intervention and control of the machine vision system is required affects many system elements, particularly software. If operators are required to periodically change inspection criteria, such as acceptance tolerances that, the software must support such changes. Software may also need to provide security to prevent unauthorized access and parameter changes, and include safeguards to avoid the introduction of erroneous parameter values. Software design can affect the type and degree of training operators will require as well as the ease of system maintenance and modification.

Building a Machine Vision System While the answers to these questions depend on the application, all machine vision systems for factory automation share some fundamental attributes and behaviors. Vision systems all must have an image to inspect a scene or object, operating on a continuous basis, and at the fastest practical speed. Systems all operate by using the following steps: • Position the part or camera so that the camera can view the part • Capture an image with a camera • Process the image • Take action based on the image processing results • Communicate results to operators and other factory systems Because of this commonality, examination of a specific application such as inspection of objects on an assembly line will illustrate methods by which developers can build a suitable machine vision system for their application. The essential elements of an inspection system, shown in Figure, include a delivery system, the vision system, the response system, and sensors to trigger image capture and system response. The delivery system positions the part for inspection. The vision system, which includes camera, optics, lighting, and image processor, captures and processes the object image to determine a pass/fail response. The response system takes the required action as well as communicating results to operators or other systems. The sensors serve to trigger the vision and response systems, identifying when the object is positioned properly for the systems to perform their tasks.

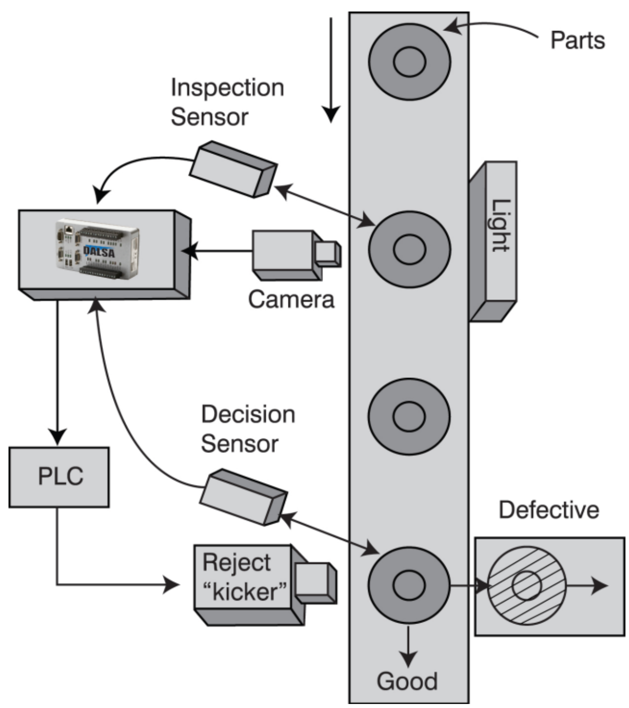


Figure: A machine vision inspection system needs a delivery vehicle as well as a means of taking action when parts fail.

Impact of robotic advances and AI—Self-driving cars, intelligent digital agents that can act for you, and robots are advancing rapidly. Will networked, automated, artificial intelligence (AI) applications and robotic devices have displaced more jobs than they have created by 2025? Half of these experts (48%) envision a future in which robots and digital agents have displaced significant numbers of both blue- and white-collar workers—with many expressing concern that this will lead to vast increases in income inequality, masses of people who are effectively unemployable, and breakdowns in the social order.

Robotics is the branch of mechanical engineering, electrical engineering and computer science that deals with design, construction, and as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines (robots for short) that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behaviour, and or cognition. Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics. The concept of creating machines that can operate autonomously dates back to classical times, but research into the functionality and potential uses of robots did not grow substantially until the 20th century. Throughout history, it has been frequently assumed that robots will one day be able to mimic human behavior and manage tasks in a human-like fashion. Today, robotics is a rapidly growing field, as technological advances continue; researching, designing, and building new robots serve various practical purposes, whether domestically, commercially, or militarily. Many robots are built to do jobs that are hazardous to people such as defusing bombs, finding survivors in unstable ruins, and exploring mines and shipwrecks. Robotics is also used in STEM (Science, Technology, Engineering, and Mathematics) as a teaching aid.

Sensors in Robotics: The use of sensors in robots has taken them into the next level of creativity. Most importantly, the sensors have increased the performance of robots to a large extent. It also allows the robots to perform several functions like a human being. The robots are even made intelligent with the help of Visual Sensors (generally called as machine vision or computer vision), which helps them to respond according to the situation. The Machine Vision system is classified into six sub-divisions such as Pre-processing, Sensing, Recognition, Description, Interpretation, and Segmentation.

Different types of sensors: There are plenty of sensors used in the robots, and some of the important types are listed below: Proximity Sensor, Range Sensor, and Tactile Sensor.

Proximity Sensor: This type of sensor is capable of pointing out the availability of a component. Generally, the proximity sensor will be placed in the robot moving part such as end effector. This sensor will be turned ON at a specified distance, which will be measured by means of feet or millimeters. It is also used to find the presence of a human being in the work volume so that the accidents can be reduced.

Range Sensor: Range Sensor is implemented in the end effector of a robot to calculate the distance between the sensor and a work part. The values for the distance can be given by the workers on visual data. It can evaluate the size of images and analysis of common objects. The range is measured using the Sonar receivers & transmitters or two TV cameras.

Tactile Sensors: A sensing device that specifies the contact between an object, and sensor is considered as the Tactile Sensor. This sensor can be sorted into two key types namely: Touch Sensor, and Force Sensor. The touch sensor has got the ability to sense and detect the touching of a sensor and object. Some of the commonly used simple devices as touch sensors are micro – switches, limit switches, etc. If the end effector gets some contact with any solid part, then this sensor will be handy one to stop the movement of the robot. In addition, it can be used as an inspection device, which has a probe to measure the size of a component. The force sensor is included for calculating the forces of several functions like the machine loading & unloading, material handling, and so on that are performed by a robot. This sensor will also be a better one in the assembly process for checking the problems. There are several techniques used in this sensor like Joint Sensing, Robot – Wrist Force Sensing, and Tactile Array Sensing.

Factory Robots: Factories first opened their doors to modern industrial robots in 1961. That's when Unimate joined the General Motors workforce. Unimate was essentially a 4,000-pound (1,814-kilogram) arm attached to a giant steel drum. The Unimate robots boasted remarkable versatility for the time and could easily pour liquid metal into die casts, weld auto bodies together and manipulate 500-pound (227-kilogram) payloads. In other words, Unimate could perform tasks that humans often found dangerous or boring, and it could do them with consistent speed and precision. Robot factory workers aren't without their limitations, however. In their simplest forms, industrial robots are mere automatons. Humans program them to perform a simple task, and they repeat that task over and over again. Tasks that require decision-making, creativity, adaptation and on-the-job learning tend to go to the humans. But when a job's just right for a robot, productivity tends to increase dramatically. For instance, Australia's Drake Trailers installed a single welding robot on its production line and benefited from a reported 60 percent increase in productivity. The most obvious impact of industrial mechanization is that it eliminates many unskilled job positions. Industrial robots, therefore, have been a true advantage in that they fill unwanted factory jobs and create more technical positions dedicated to their upkeep. In the same way that a computerized office depends on various techies, so too do robotic workers require technical upkeep.

A personal robot is one whose human interface and design make it useful for individuals. This is by contrast to industrial robots which are generally configured and operated by robotics specialists. A personal robot is one that enables an individual to automate the repetitive or menial part of home or work life making them more productive. A domestic robot, or service robot, is an autonomous robot that is used for household chores. Many domestic robots are used for basic household chores. Others are educational or entertainment robots, such as the HERO line of the 1980s. While most domestic robots are simplistic, some are connected to WiFi home networks or smart environments and are autonomous to a high degree.

Robotic engineers are designing the next generation of robots to look, feel and act more human, to make it easier for us to warm up to a cold machine. Realistic looking hair and skin with embedded sensors will allow robots to react naturally in their environment. For example, a robot that senses your touch on the shoulder and turns to greet you. Subtle actions by robots that typically go unnoticed between people, help bring them to life and can also relay non verbal communication. Artificial eyes that move and blink. Slight chest movements that simulate breathing. Man made muscles to change facial expressions. These are all must have attributes for the socially acceptable robots of the future.