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## Advanced Image Processing Systems

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### ABSTRACT

*Image processing is a subset of digital signal processing that has different applications and benefits in different fields. Digital processing is in fact the digital image processing that can be performed with the help of computer science, programming and artificial intelligence. Image processing is one of the applications and subsets of artificial intelligence that, as its name suggests, processes digital images and displays a certain output with specific information based on predefined training. Nowadays, the applications of image processing technology in various fields of science, technology have caused a lot of attention in order to expand the capabilities of artificial intelligence in different engineering challenges. This paper presents recent development and applications in the image processing systems in order to move forward the research filed by reviewing and analyzing recent achievements in the published papers. As a result, advanced image processing systems in different applications can be developed and new techniques in the image processing systems can be introduced.*

**Keywords:** Image processing, Computer vision, Computer graphics.

**Mathematics Subject Classification:** 68N01, 68N17

**Computing Classification System:** I.4

### 1. INTRODUCTION

Today, the use of computers as an efficient tool has facilitated the control of engineering systems, data collection, data analysis, data processing and even decision-making at various stages of a process. Image processing Nowadays, digital image processing is a branch of computer science that deals with the processing of digital signals that represent images taken with a digital camera or scanned by a scanner. (Cosido et al. 2014). Image Processing is now called digital image processing, which requires computer knowledge and processes the digital signal picked up by a camera or scanner. Image processing is one of the basic components in intelligent systems where decisions are made. This processing is applied to digital images by computer systems. Diverse applications of image processing in various technical, industrial, urban, medical and scientific fields have made it a very active topic among research fields.

Image processing has two main branches: improving images and machine vision. Improving images includes methods such as using a blur filter and increasing contrast to improve the visual quality of

images and ensure that they are displayed correctly in the destination environment (such as a chipper or computer monitor), while machine vision deals with methods. With their help, the meaning and content of images can be understood to be used in works such as robotics and image axis (Mohan and Poobal 2018). In its specific sense, image processing is any type of signal processing that is the input of an image, such as a photo or a scene from a movie. The output of the image processor can be an image or a set of special symbols or image-related variables. Most image processing techniques involve dealing with the image as a two-dimensional signal. Apply standard signal processing techniques on them. Image processing often refers to digital image processing, but there are also optical and analog image processing.

## 2. LITERATURE REVIEW

Geometric adjustments such as resizing, rotating, and color adjustment are main image processing operations. There are also other processing techniques such as mixing images with brightness, sharpness or color space and merging two or more images that compress images, such as decreasing image size areas that increase file quality, such as decreasing noise and increasing contrast. Application of the Secure Socket Layer in the Network and Web Security is investigated by Dastres and Soori (Dastres and Soori 2020) to increase the security measures in the web of data. The impact of meltdown hole on various processors and operating systems are studied by Dastres and Soori (Dastres and Soori 2020) in order to increase security of CPU manufacture by preventing the capturing data on computer or smartphones by attackers.

Image processing has two main branches: image enhancement and machine vision. Improving images includes methods such as using a blur filter and increasing contrast to improve the visual quality of images and ensure that they are displayed correctly in the target environment, such as a printer or computer monitor. While machine vision deals with methods that can be used to understand the meaning and content of images to be used in tasks such as robotics and image axis (Lukac, Martin, and Platanoitis 2004). The steps of image processing in increasing the quality of images is shown in the Figure 1 ("Web page for image processing ").



Fig. 1 Steps of image processing ("Web page for image processing ").

## 2.1. TYPES OF IMAGE PROCESSING

In order to apply the image processing techniques to the different images, treating the image as a two-dimensional signal and applying standard signal processing techniques are considered.

There are two types of analog and digital image processing methods. The analog technique is used for image processing for hard versions such as photo printing. Digital image processing is used for a variety of applications, from satellite image analysis to microscopic dimension control, which is better known today. The image processing can be divided into three general categories:

1. Low level processing: It includes basic processing such as noise cancellation, image filtering, and contrast (Fan et al. 2017).
2. Intermediate level processing: The peculiarity of this process is that its input is usually an image and its output are attributes of image objects such as edges, contours and object recognition (Fan et al. 2017).
3. High level processing: This process involves understanding the relationship between the objects detected, inferring and interpreting the scene, and performing the interpretations and diagnoses that the human visual system performs (Fan et al. 2017).

## 2.2. DIFFERENT TECHNIQUES IN IMAGE PROCESSING

The different techniques in the image processing systems is presented in this section to provide a review from the developed methodology of the image processing systems in different applications.

### 2.2.1. IMAGE ZONING

Image zoning is the separation of image pixels into separate areas that are the same in terms of brightness, texture, or color, or are as correlated as possible. Image zoning is an essential need to start processing in many processing applications such as image therapy, machine vision, image compression, object science (Vellingiriraj, Balamurugan, and Balasubramanie 2016). An image before Zoning (Feature Extraction) and after zoning is shown in the Figure 2 [6].

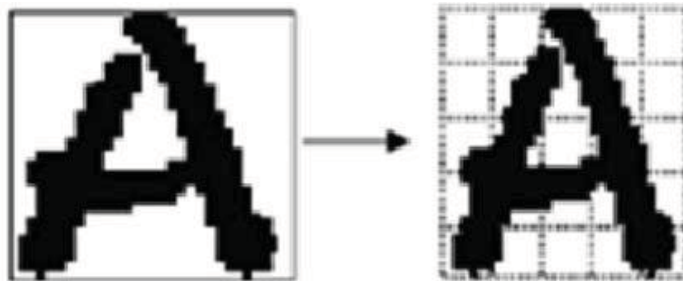


Fig. 2 An example of image Zoning [6].

2-2-2-Object Recognition: The process of object recognition, from the simplest analysis to the most advanced analysis possible, is done by seeing an image. In the process of object recognition, the moving paths of an image is followed by the system in order to be analyzed (Li, Su, et al. 2018). An example of object recognition in the car traffic analysis systems is shown in the Figure 3 (Harikrishnan et al. 2020).



Fig. 3 An example of object recognition in the car traffic analysis systems (Harikrishnan et al. 2020).

### 2.2.2. FACE DETECTION

Face detection is one of several biometric methods that has high accuracy and unlike other validation methods, the user can easily enter the validation process with his own face. Face recognition by computer is one of the most attractive fields of biometric research that includes various scientific fields such as machine vision, computational intelligence, pattern recognition and psychology. Therefore, the use of software equipped with a human face recognition system can significantly increase the reliability of traffic control systems, especially at the borders and entry points of the country. Also, the face recognition is widely used in robotics to save human life in the dangerous conditions (Deshpande and Ravishankar 2017; Qi et al. 2019). An example of the face recognition system is shown in the Figure 4 ("Image processing systems").



Fig. 4 An example of the face recognition system ("Image processing systems").

Each face recognition system consists of four main parts as structure and process of face recognition system: 1-Imaging and detection, 2-Pre-processing, 3-Extraction of features, 4-Implementation and decision making.

An advanced face reorganization systems based on the three layers of convolution neural network (CNN) is developed by Altameem and Altameem (Altameem and Altameem 2020) to increase the power of face detection system in the image processing applications of the healthcare systems. The process of visualization analysis is shown in the Figure 5 (Altameem and Altameem 2020).

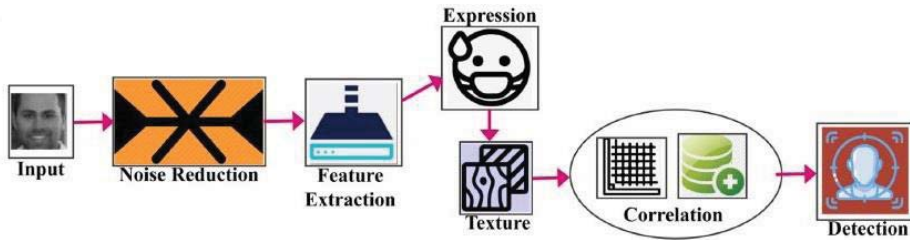


Fig. 5 The process of visualization analysis (Altameem and Altameem 2020).

Three layers, such as texture classification, correlation, and facial visualization detection using stored information, are applied in the proposed method. The input is the facial image, so key characteristics are extracted and analyzed in time, avoiding misdetection and calculation steps. The neural network that classifies the characteristics and recognizes them is CNN.

Moreover, an algorithm is developed in the face detection applications based on extracting multi-resolution properties. By applying this algorithm, the processing speed will be greatly increased, in fact, with this algorithm, it will extract more effective features and impose less processing load on the program. Figure 6 shows the process of applying the discrete waveform function method to the face detection process.

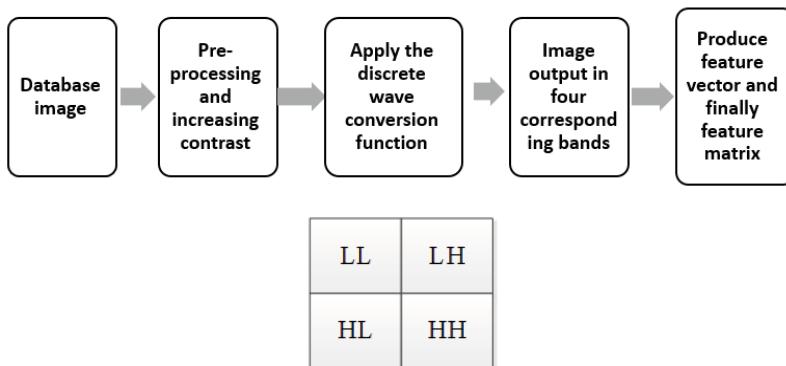


Fig. 6 A) The process of applying the discrete wave conversion function B) Output image (LL indicating approximation, LH horizontal substructure, HH diagonal substructure, HL vertical substructure).



Implementation and decision making phase is the final step of face detection algorithm. The system compares all database features with the database images and based on this comparison, the desired image class (person) is determined. Types of classifiers used in face recognition include classifiers for the nearest neighbor support vector machine, and artificial neural networks. Figure 7 shows the example of database images ("Web page for example of database images").

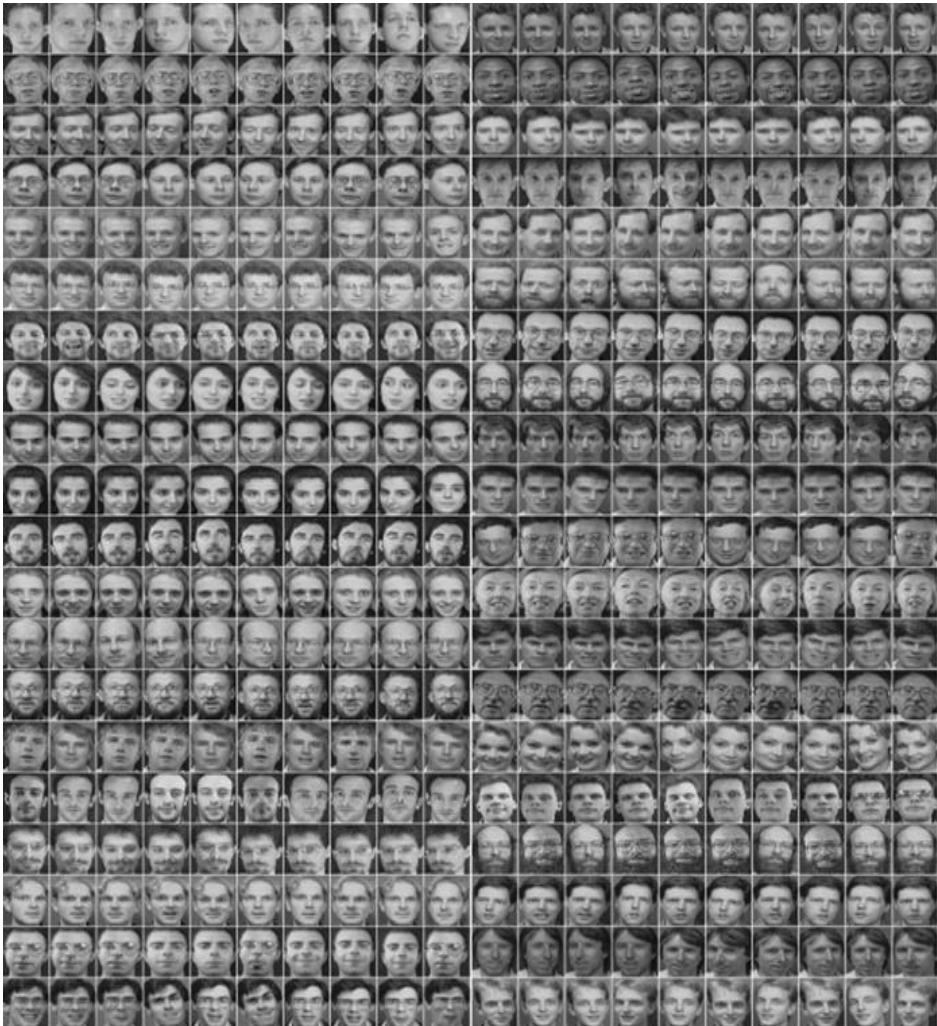
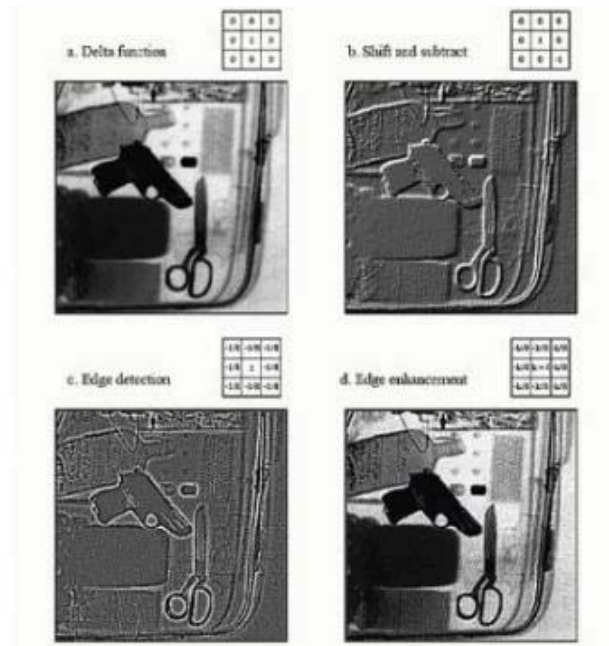


Fig. 7 Example of database images ("Web page for example of database images").

### 2.2.3. THE EDGE RECOGNITION PROCESS

The edge recognition is one of the most efficient and useful techniques in image processing, especially in separating and identifying the main image frame. There are different ways to detect an edge in an image, such as the loss of original image data and the inability to find the edge at different angles. The purpose of edge detection is to define the boundaries of objects in an image that are the basis of image analysis and machine vision (Woodhouse 2017). An example of the edge recognition process in image processing systems is shown in the Figure 8 (Woodhouse 2017).



**Fig. 8** An example of the edge recognition process in image processing systems (Woodhouse 2017).

### 2.3. IMAGE COMPRESSION METHODS IN IMAGE PROCESSING

Image compression means discarding pieces of information and tensors. Which reduces the required bandwidth and frequency and makes them easier to store and transmit. A compression ratio is a number that indicates the rate at which information is discarded (Agustsson et al. 2019).

#### 2.3.1. JPEG METHOD

This name stands for Joint Photographic Expert Group, which is used to compress still graphic images. JPEG is the first and easiest way to compress an image, which was tried to be compressed frame by frame for moving images, and Motion JPEG was used to connect these images, which had problems.

#### 2.3.2. THE MPEG METHOD

The method stands for Moving Picture Expert Group, in which image data was transmitted at about 5.1 Mbps, which was used for video images. This method allows you to store about 650 MB of data equivalent to about 70 minutes of moving image on a disk. In MPEG, information is sent serially, along with control and coordinate bits, which determine the location and placement of information bits to record audio and video information (Li, Zuo, et al. 2018; Minnen, Ballé, and Toderici 2018).

#### 2.3.3. THE MPEG 2 METHOD

This method uses a higher compression ratio and access to data is 3 to 15 Mbps, which is used in today's DVDs. Each frame of the image contains several lines of digital information.



#### 2.3.4. MPEG 4 METHOD

This method is used for equipment that deals with fast or slow data transfer that has the ability to compensate for errors and provide high quality image. In computer networks, the image should be displayed well for all users who work with different modem speeds, which is suitable for MPEG 4 method. The main idea of this method is to divide a video frame into one or more subjects, which are put together according to a certain rule, and each of them contains an audio or video subject and can be copied or transferred separately. We can use common components only once and refer to them when creating a theme, and we can even create a new collection by combining themes. This has led to the flexibility and widespread use of the MPEG 4 method (Minnen, Ballé, and Toderici 2018).

### 2.4. IMAGE RESOLUTION IN THE IMAGE PROCESSING

In the visual sciences, the ability of a system to differentiate the details of an image in an image signal. Often this type of resolution depends on the size of the image pixels, and the resolution of the image can be measured in units of lines per unit length (Baron, Hill, and Elmiligi 2018).

#### 2.4.1. PIXEL RESOLUTION

If our criterion for resolution is the number of pixels, in the image below it can be easily seen that the more pixels, the clearer the image will be. But the image may have a large number of pixels but not a good spatial resolution (Bleyer 2020). The process of pixel resolution in the image processing application is shown in the Figure 9 (Ahmad, Najam, and Ahmed 2013).

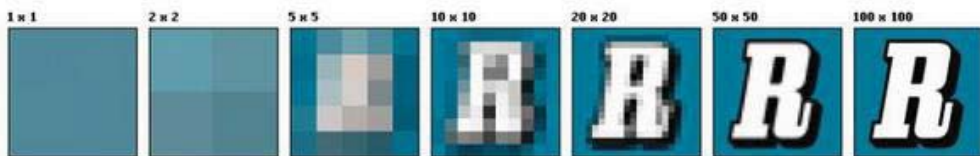


Fig. 9 The process of pixel resolution in the image processing application (Ahmad, Najam, and Ahmed 2013).

#### 2.4.2. SPATIAL RESOLUTION

In radiology, it is the ability of the imaging system to separate two objects. Low-resolution spatial techniques are incapable of separating two objects that are too close together. And they cannot distinguish between two objects. The extent to which two lines can be separated in an image determines the spatial resolution, and depends on the properties of the imaging system, not the number of pixels in the image (Chen et al. 2018).

#### 2.4.3. TIME RESOLUTION

Accuracy of measurement goes back in time. A video consists of several frames. The more frames, the higher the time resolution and the better the movement of moving objects. Of course, the time resolution must be faster than the speed of objects in order to be able to follow the movements. If the number of frames is too high, we will see a slow image, like slow scenes in football, an interesting

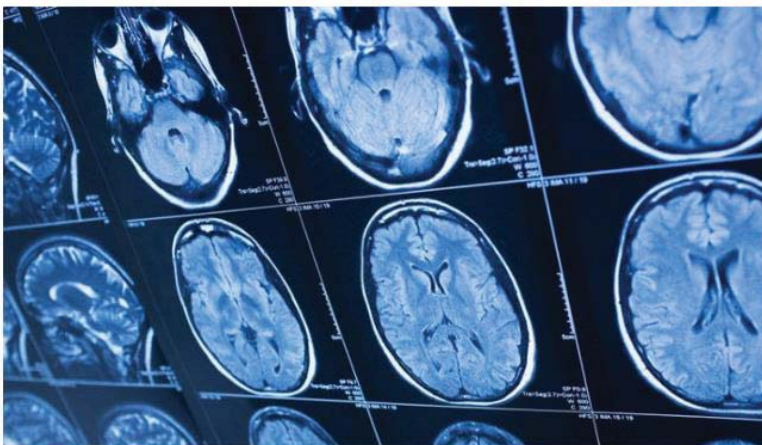
point is that if the time resolution is the same as the speed of objects, we will see a still image. Because we cannot see the changes (Shi et al. 2016).

## 2.5. IMAGE PROCESSING APPLICATIONS

As a result of new technology development, the applications of the image processing in the different areas are recently expanded. Today, with the development of imaging systems and image processing algorithms, a new branch of quality control and instrumentation has emerged, and significant advances in this field is recently presented. To increase quality of produced parts, applications of the image processing systems are developed in the manufacturing industries (Qiu 2018). Application of image processing systems in the quality control of food industries is developed to increase added values in the food industries (Du and Sun 2004). Application of image processing systems in the rice grain grading process is develop by Kuchekar and Yerigerito (Kuchekar and Yerigeri 2018) to increase the added values in the rice farming process. A review of advanced bridge inspection technologies based on robotic and image processing systems is developed by Jo et al. (Jo et al. 2018) to measure various bridge conditions, such as apparent damage, displacement and dynamic characteristics.

Image recognition technology has a lot to offer in the healthcare industry such as upgrading the features of X-ray images, MRI and CT-Scan imaging. This technology interprets the patient's medical data significantly during the patient's treatment. Medical image forgery detection for smart healthcare systems are developed by Ghoneim et al. (Ghoneim et al. 2018) in order to increase the quality of healthcare industry.

Microscopic treatments use computer vision and image recognition for diagnosis. Emotion detection with the help of artificial intelligence is also one of the applications of image processing that can be used to detect the patient's emotions during the treatment process (McAuliffe et al. 2001). Application of the image processing in the medical data analysis is shown in the Figure 10 ("Web Page of medical data analysis ").



**Fig. 10** Application of the image processing in the medical data analysis ("Web Page of medical data analysis ").

Security application such as motion detection in alarms, fingerprint recognition, face recognition and signature (Izario et al. 2017). Automatic system to control and secure the home, based on digital image processing with the help of Internet of Things (IOT) is developed by Beatrice Dorothy et al. (Dorothy, Kumar, and Sharmila 2017) to increase security of homes against robbery.

Military application such as automatic detection and tracking of moving or stationary targets from the air or from the ground. Also, the military robots are developed by using the image processing applications (Ghouse, Hiwrale, and Ranjan 2017). Air and satellite remote sensing application such as upgrade and analysis of aerial and satellite images which are useful in surveying, agriculture, meteorology and other applications (Joyce et al. 2009). Application of the image processing systems in the analysis of aerial and satellite images is shown in the Figure 11 ("Web page of aerial and satellite images ").



**Fig. 11** Application of the image processing systems in the analysis of aerial and satellite images ("Web page of aerial and satellite images ").

Multiple plant diseases identification system using digital image processing is developed by Barbedo et al. (Barbedo, Koenigkan, and Santos 2016) to increase accuracy of disease detection in gardening applications. Study of digital image processing techniques for leaf disease detection and classification is developed by Dhingra et al. (Dhingra, Kumar, and Joshi 2018) to increase the efficiency in gardening and farming industries. Application of the image processing systems in smart framing process is developed by Jhuria et al. (Jhuria, Kumar, and Borse 2013) to detect the diseases of fruits in gardening industries. To develop the smart farming systems, image processing-based intelligent robotic system for assistance of agricultural crops is developed by Paliwal et al. (Paliwal et al. 2019) Industrial applications related to industry automation such as segregation of different products by shape or size, detection of defects and fractures in products, locating objects and components of the production process b using robots and machine vision (Meriaudeau, Renier, and Truchetet 1996).

Application of the image processing systems in the assemble process of car industries is shown in the Figure 12 ("Web page for assemble process of car industries ").



**Fig. 12** Application of the image processing systems in the assemble process of car industries ("Web page for assemble process of car industries ").

To develop the efficiency of concrete production in construction engineering, crack identification system by using a UAV incorporating hybrid image processing is developed by Kim et al. (Kim et al. 2017). Application of image processing systems in surface defect detection system of tiling Industries is developed by Karimi and Asemani (Karimi and Asemani 2014) to increase quality of part production in ceramic and tile industries. A robotic welding system using image processing techniques and a CAD model is developed by Sanders et al. (Sanders et al. 2010) to provide information to a multi - intelligent decision module systems.

There are many technologies that are used to move a car automatically, but the main technology that prevents road accidents is reading traffic signs, recognizing objects or people on the road, and image processing technology (Eamthanakul, Ketcham, and Chumuang 2017). Smart parking system with image processing facility is developed by Reza et al. (Reza et al. 2012) to increase quality of car production options such as automated parking system for the customers. Moreover, the Image processing will have many applications in the retail industry. An RFID-based visual product recognition system for the retail industry is developed by (Sun 2016) to improve customer in-store shopping experience.

From image processing of sales and consumer goods to recognizing their price and quality or identifying customers and buyers, is one of the applications of image processing in the retail industry (Graciola et al. 2018). Also, the image recognition is one of the most important technologies that has made a huge difference in the gaming industry . For example, in the wake of current developments, advanced image recognition technology allows gamers to use their actual location as an in-game battlefield for virtual adventures (Sangüesa et al. 2016). Application of the image processing systems in the game industries is shown in the Figure 13.





**Fig. 13** Application of the image processing systems in the game industries.

Image processing is a very practical technology in the world of social networks. Image processing is used to examine the content of images, and this is a very useful issue for many people, including marketers. Image recognition tools perform various social network search operations to find specific images and are able to provide many benefits to customers (Marra et al. 2018). The aim is to increase the power of networks to recognize the people pictures in their profiles. Application of the image processing systems in the social networks is shown in the Figure 14.



**Fig. 14** Application of the image processing systems in the social networks.

Image search engines use image processing technology to provide the best image search results in the picture and video search engines. Google and Bing, for example, are two older image search engines that have a high level of image processing technology (Uyar and Karapinar 2017). The recent development in applications of the image processing is presented in the Table 1.



| No. | Applications                | Papers   | Definitions  |
|-----|-----------------------------|--|--|
| 1   | Quality control             | (Njoroge et al. 2002; Du and Sun 2004)                       | To grade the quality of fruits in the marketing, the image processing system is applied.   |
| 2   | Healthcare industry         | (McAuliffe et al. 2001; Pandit and Shah 2011)                | To increase the effects of medical process to the patients, the images of the brain and palm are analyzed.   |
| 3   | Security applications       | (Izario et al. 2017; Surve 2020)                             | An advanced monitoring and filtering systems for the security cameras in markets and banks is developed to decrease the level of criminal activities.              |
| 4   | Military applications       | (Ghouse, Hiwrale, and Ranjan 2017)                           | To develop the military robots in the defense industries, application of image processing is applied.  |
| 5   | Aerial and satellite images | (Joyce et al. 2009; Yuan, Liu, and Zhang 2017)               | To create an advanced map of natural hazardous and forest fire detection, application of image processing systems in the Aerial and satellite images is developed. |
| 6   | Automotive industry         | (Meriaudeau, Renier, and Truchetet 1996; Korodi et al. 2020) | To increase accuracy and efficiency in process of car manufacturing and assembly process, the image processing systems are applied to the automotive industries.   |
| 7   | Smart farming               | (Barbedo, Koenigkan, and Santos 2016)                        | To increase accuracy of disease detection in gardening applications, multiple plant diseases identification system using digital image processing is developed.    |
| 8   | Retail industry             | (Graciola et al. 2018)                                       | To increase the added value in the marketing process, applications of image processing in the retail industry is developed.  |
| 9   | Gaming industry             | (Sangüesa et al. 2016)                                       | To develop the game engine in the gaming industries, application of the image processing systems is developed.   |
| 10  | Social networks             | (Marra et al. 2018)  | To increase the abilities of social networks in picture detection and filtration process, application of image processing is developed.                            |
| 11  | Internet search engines     | (Uyar and Karapinar 2017)                                    | To provide the best image search results in the picture and video search engines, application of image processing systems is developed.                            |

### 3. CONCLUSION

Image Processing is now called digital image processing, which requires computer knowledge and processes the digital signal picked up by a camera or scanner. Image processing is a method in which an image is received as input and by performing a series of operations on it, an image or a set of special symbols or variables related to the image is received as its output. In image processing, input contains image content, which by performing a series of operations on it. Also, the output includes a

set of special symbols or variables related to the image. These outputs can include the following: These outputs can be 1. View and print the image. 2. Image editing. 3. Image enhancement. 4. Discover a specific feature in the image. 5. Image compression. The applications of the image processing systems in the Quality control, Healthcare industry, Security applications, Military applications, Aerial and satellite images, Automotive industry, Retail industry, Gaming industry, Smart farming systems, Social networks and Internet search engines are currently analyzed in the recent published works. The systems can be expanded to the sport applications to analyze the game videos and find the winner of the sport completions such football. Radar signal processing to increase the capabilities of communication is another application of the image processing in data analysis systems. Automated driver system of advanced car can use image processing system to decrease the rate of accident in driving. Also, car number detection systems in the traffic management by the police is also an important issue of image processing application which can be developed in the future research works. The image processing can be used in the pattern recognition system to develop the good marketing industries. Different image processing systems can be connected together in web of data to share the advantages and capacities. So, the advantages of different image processing systems can be increased in order to expand the engineering applications in human life. These are suggestions for the future research works in order to develop the applications of image processing systems in different engineering fields.

#### 4. REFERENCES

- Agustsson, Eirikur, Michael Tschannen, Fabian Mentzer, Radu Timofte, and Luc Van Gool. 2019. Generative adversarial networks for extreme learned image compression. Paper presented at the Proceedings of the IEEE International Conference on Computer Vision.
- Ahmad, Faizan, Aaima Najam, and Zeeshan Ahmed. 2013. "Image-based face detection and recognition:" state of the art"." Review of. *arXiv preprint arXiv:1302.6379*.
- Altameem, Torki, and Ayman Altameem. 2020. "Facial expression recognition using human machine interaction and multi-modal visualization analysis for healthcare applications." Review of. *Image and Vision Computing* **103**:104044.
- Barbedo, Jayme Garcia Arnal, Luciano Vieira Koenigkan, and Thiago Teixeira Santos. 2016. "Identifying multiple plant diseases using digital image processing." Review of. *Biosystems engineering* **147**:104-16.
- Baron, Jackson, DJ Hill, and H Elmiligi. 2018. "Combining image processing and machine learning to identify invasive plants in high-resolution images." Review of. *International Journal of Remote Sensing* **39 (15-16)**:5099-118.
- Bleyer, Jeremy. 2020. "Automating the formulation and resolution of convex variational problems: applications from image processing to computational mechanics." Review of. *ACM Transactions on Mathematical Software (TOMS)* **46 (3)**:1-33.
- Chen, Yangyang, Dongping Ming, Lu Zhao, Beiru Lv, Keqi Zhou, and Yuanzhao Qing. 2018. "Review on high spatial resolution remote sensing image segmentation evaluation." Review of. *Photogrammetric Engineering & Remote Sensing* **84 (10)**:629-46.

Cosido, Oscar, Andres Iglesias, Akemi Galvez, Raffaele Catuogno, Massimiliano Campi, Leticia Terán, and Esteban Sainz. 2014. Hybridization of convergent photogrammetry, computer vision, and artificial intelligence for digital documentation of cultural heritage-a case study: the magdalena palace. Paper presented at the 2014 International Conference on Cyberworlds.

Dastres, Roza, and Mohsen Soori. 2020. "Impact of Meltdown and Spectre on CPU Manufacture Security Issues." Review of. *International Journal of Engineering and Future Technology* **18** (2):62-9.

Dastres, Roza, and Mohsen Soori. 2020. "Secure Socket Layer in the Network and Web Security." Review of. *International Journal of Computer and Information Engineering* **14** (10):330-3.

Deshpande, Narayan T, and S Ravishankar. 2017. "Face Detection and Recognition using Viola-Jones algorithm and Fusion of PCA and ANN." Review of. *Advances in Computational Sciences and Technology* **10** (5):1173-89.

Dhingra, Gittaly, Vinay Kumar, and Hem Dutt Joshi. 2018. "Study of digital image processing techniques for leaf disease detection and classification." Review of. *Multimedia Tools and Applications* **77** (15):19951-20000.

Dorothy, A Beatrice, S Britto Ramesh Kumar, and J Jerlin Sharmila. 2017. IoT based home security through digital image processing algorithms. Paper presented at the 2017 World Congress on Computing and Communication Technologies (WCCCT).

Du, Cheng-Jin, and Da-Wen Sun. 2004. "Recent developments in the applications of image processing techniques for food quality evaluation." Review of. *Trends in food science & technology* **15** (5):230-49.

Eamthanakul, Busarin, Mahasak Ketcham, and Narumol Chumuang. 2017. The traffic congestion investigating system by image processing from cctv camera. Paper presented at the 2017 International Conference on Digital Arts, Media and Technology (ICDAMT).

Fan, Zunlin, Duyan Bi, Linyuan He, Ma Shiping, Shan Gao, and Cheng Li. 2017. "Low-level structure feature extraction for image processing via stacked sparse denoising autoencoder." Review of. *Neurocomputing* **243**:12-20.

Ghoneim, Ahmed, Ghulam Muhammad, Syed Umar Amin, and Brij Gupta. 2018. "Medical image forgery detection for smart healthcare." Review of. *IEEE Communications Magazine* **56** (4):33-7.

Ghouse, Zubair, Nishika Hiwrale, and Nihar Ranjan. 2017. "Military Robot for Reconnaissance and Surveillance using Image Processing." Review of. *International Research Journal of Engineering and Technology* **4** (5).

Graciola, Ana Paula, Deonir De Toni, Vinicius Zanchet de Lima, and Gabriel Sperandio Milan. 2018. "Does price sensitivity and price level influence store price image and repurchase intention in retail markets?" Review of. *Journal of Retailing and Consumer Services* **44**:201-13.

Harikrishnan, PM, Anju Thomas, JS Nisha, Varun P Gopi, and P Palanisamy. 2020. "Pixel matching search algorithm for counting moving vehicle in highway traffic videos." Review of. *Multimedia Tools and Applications*:1-20.

"Image processing systems." 2020. <https://elceo.com/tecnologia/el-reconocimiento-facial-transformara-los-servicios-pero-la-gente-teme-por-una-mayor-vigilancia/>.

Izario, Daniel, Yuzo Iano, Bruno Izario, and Diego Castro. 2017. Digital Image Processing with Data Storage for Security Applications. Paper presented at the Brazilian Technology Symposium.

Jhuria, Monika, Ashwani Kumar, and Rushikesh Borse. 2013. Image processing for smart farming: Detection of disease and fruit grading. Paper presented at the 2013 IEEE Second International Conference on Image Information Processing (ICIIP-2013).

Jo, Byung-Wan, Yun Sung Lee, Jung-Hoon Kim, and Kwang-Won Yoon. 2018. "A review of advanced bridge inspection technologies based on robotic systems and image processing." Review of. *International Journal of Contents* **14 (3)**.

Joyce, Karen E, Stella E Belliss, Sergey V Samsonov, Stephen J McNeill, and Phil J Glassey. 2009. "A review of the status of satellite remote sensing and image processing techniques for mapping natural hazards and disasters." Review of. *Progress in physical geography* **33 (2)**:183-207.

Karimi, Mohammad H, and Davud Asemani. 2014. "Surface defect detection in tiling Industries using digital image processing methods: Analysis and evaluation." Review of. *ISA transactions* **53 (3)**:83-44.

Kim, Hyunjun, Junhwa Lee, Eunjong Ahn, Soojin Cho, Myoungsu Shin, and Sung-Han Sim. 2017. "Concrete crack identification using a UAV incorporating hybrid image processing." Review of. *Sensors* **17 (9)**:2052.

Korodi, Adrian, Denis Anitei, Alexandru Boitor, and Ioan Silea. 2020. "Image-processing-based low-cost fault detection solution for end-of-line ECUs in automotive manufacturing." Review of. *Sensors* **20 (12)**:3520.

Kuchekar, NA, and VV Yerigeri. 2018. "Rice grain quality grading using digital image processing techniques." Review of. *IOSR J Electronics Communication Eng* **13 (3)**:84-8.

Li, Heng, Xiaofan Su, Jing Wang, Han Kan, Tingting Han, Yajie Zeng, and Xinyu Chai. 2018. "Image processing strategies based on saliency segmentation for object recognition under simulated prosthetic vision." Review of. *Artificial intelligence in medicine* **84**:64-78.

Li, Mu, Wangmeng Zuo, Shuhang Gu, Debin Zhao, and David Zhang. 2018. Learning convolutional networks for content-weighted image compression. Paper presented at the Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition.

Lukac, Rastislav, Karl Martin, and KN Platanoitis. 2004. "Digital camera zooming based on unified CFA image processing steps." Review of. *IEEE Transactions on Consumer Electronics* **50 (1)**:15-24.

Marra, Francesco, Diego Gagnaniello, Davide Cozzolino, and Luisa Verdoliva. 2018. Detection of gan-generated fake images over social networks. Paper presented at the 2018 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR).

McAuliffe, Matthew J, Francois M Lalonde, Delia McGarry, William Gandler, Karl Csaky, and Benes L Trus. 2001. Medical image processing, analysis and visualization in clinical research. Paper presented at the Proceedings 14th IEEE Symposium on Computer-Based Medical Systems. CBMS 2001.

Meriaudeau, Fabrice, Eric Renier, and Frederic Truchetet. 1996. "Temperature imaging and image processing in the steel industry." Review of. *Optical Engineering* **35 (12)**:3470-81.

Minnen, David, Johannes Ballé, and George D Toderici. 2018. Joint autoregressive and hierarchical priors for learned image compression. Paper presented at the Advances in Neural Information Processing Systems.

Mohan, Arun, and Sumathi Poobal. 2018. "Crack detection using image processing: A critical review and analysis." Review of. *Alexandria Engineering Journal* **57 (2)**:787-98.

Njoroge, John B, Kazunori Ninomiya, Naoshi Kondo, and Hideki Toita. 2002. Automated fruit grading system using image processing. Paper presented at the Proceedings of the 41st SICE Annual Conference. SICE 2002.

Paliwal, Nikhil, Pankhuri Vanjani, Jing-Wei Liu, Sandeep Saini, and Abhishek Sharma. 2019. "Image processing-based intelligent robotic system for assistance of agricultural crops." Review of. *International Journal of Social and Humanistic Computing* **3 (2)**:191-204.

Pandit, Hardik, and Dr M Shah. 2011. Application of Digital Image Processing and analysis in healthcare based on Medical Palmistry. Paper presented at the International Conference on Intelligent Systems and Data Processing (ICISD).

Qi, Rong, Rui-Sheng Jia, Qi-Chao Mao, Hong-Mei Sun, and Ling-Qun Zuo. 2019. "Face detection method based on cascaded convolutional networks." Review of. *IEEE Access* 7:110740-8.

Qiu, Peihua. 2018. "Jump regression, image processing, and quality control." Review of. *Quality Engineering* 30 (1):137-53.

Reza, MO, MF Ismail, AA Rokoni, and MAR Sarkar. 2012. "Smart parking system with image processing facility." Review of. *International Journal of Intelligent Systems and Applications* 4 (3):41.

Sanders, David A, Gareth Lambert, Jasper Graham-Jones, Giles E Tewkesbury, Spencer Onuh, David Ndzi, and Carl Ross. 2010. "A robotic welding system using image processing techniques and a CAD model to provide information to a multi-intelligent decision module." Review of. *Assembly Automation*.

Sangüesa, Adriá Arbués, Andreea-Daniela Ene, Nicolai Krogh Jørgensen, Christian Aagaard Larsen, Daniel Michelsanti, and Martin Kraus. 2016. "Pyramid Algorithm Framework for Real-Time Image Effects in Game Engines." In *Interactivity, Game Creation, Design, Learning, and Innovation*, 289-96. Springer.

Shi, Wenzhe, Jose Caballero, Ferenc Huszár, Johannes Totz, Andrew P Aitken, Rob Bishop, Daniel Rueckert, and Zehan Wang. 2016. Real-time single image and video super-resolution using an efficient sub-pixel convolutional neural network. Paper presented at the Proceedings of the IEEE conference on computer vision and pattern recognition.

Sun, Yongbin. 2016. "An RFID-based visual recognition system for the retail industry." Massachusetts Institute of Technology.

Surve, Apurva. 2020. Visual Cryptography and Image Processing Based Approach for Bank Security Applications. Paper presented at the Second International Conference on Computer Networks and Communication Technologies: ICCNCT 2019.

Uyar, Ahmet, and Rabia Karapinar. 2017. "Investigating the precision of Web image search engines for popular and less popular entities." Review of. *Journal of Information Science* 43 (3):378-92.

Vellingiriraj, EK, M Balamurugan, and P Balasubramanie. 2016. Information extraction and text mining of Ancient Vattezhuthu characters in historical documents using image zoning. Paper presented at the 2016 International Conference on Asian Language Processing (IALP).

"Web page for assemble process of car industries ". Accessed 30 October 2020. <http://technorail.it/technorail/index.php/en/>.

"Web page for example of database images." Accessed 30 October 2020. <https://www.owl.net/~elec539/Projects97/morphjks/moredge.html>.

"Web page for image processing ". <https://computergraphics.stackexchange.com/questions/2018/what-is-tessellation-in-computer-graphics>.

"Web page of aerial and satellite images ". Accessed 30 October 2020. <https://geology.com/below-sea-level/>.

"Web Page of medical data analysis ". Accessed 30 October 2020. <https://www.hopepaige.com/information/how-epileptic-seizures-impact-the-brain>.



Woodhouse, Chris. 2017. "Linear Image Processing: It easy to forget that sensor data is inherently linear and that some image processing algorithms, to be effective, depend on unadulterated sensor data." In *The Astrophotography Manual*, **213-22**. Routledge.

Yuan, Chi, Zhixiang Liu, and Youmin Zhang. 2017. "Aerial images-based forest fire detection for firefighting using optical remote sensing techniques and unmanned aerial vehicles." Review of *Journal of Intelligent & Robotic Systems* **88 (2-4)**:635-54.