COMPUTER VISION AND AI-INTEGRATED IOT TECHNOLOGIES IN THE MEDICAL ECOSYSTEM

EDITED BY

Alex Khang, Vugar Abdullayev, Olena Hrybiuk, and Arvind K. Shukla

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Computer Vision and AI-Integrated IoT Technologies in the Medical Ecosystem

This book examines computer vision and IoT-integrated technologies used by medical professionals in decision-making, for sustainable development in a healthcare ecosystem, and to better serve patients and stakeholders. It looks at the methodologies, technologies, models, frameworks, and practices necessary to resolve the challenging issues associated with leveraging the emerging technologies driving the medical field.

The chapters discuss machine vision, AI-driven computer vision, machine learning, deep learning, AI-integrated IoT technology, data science, blockchain, AR/VR technology, cloud data, and cybersecurity techniques in designing and implementing a smart healthcare infrastructure in the era of the Industrial Revolution 4.0. Techniques are applied to the detection, diagnosis, and monitoring of a wide range of health issues.

Computer Vision and AI-Integrated IoT Technologies in the Medical Ecosystem targets a mixed audience of students, engineers, researchers, academics, and professionals who are researching and working in the field of medical and healthcare industries from different environments and countries.

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Arvind K. Shukla has over 18 years of experience in teaching and industry. He is currently working as professor and department head at the Department of Computer Applications, IFTM University, Moradabad, India. He obtained his PhD in Computer Science from Banasthali University, Vidyapith, Rajasthan, and has published numerous research papers in national and international journals. He has consistently been an active member of the academic council, executive council, board of studies, and research degree committee of IFTM University, Moradabad. He has supervised the M Tech dissertations and PhD theses of twelve students.

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Preface

In the twenty-first century, the scope of application of AI-integrated IoT technologies in the field of healthcare and medicine is increasing. They seems human is getting closer to a world where connected smart devices tell the people when they need to visit our doctor because they are aware of health problem and discovered symptoms that might be concerning. The goals of using computer vision and IoT-integrated technologies are to constantly help medical professionals in decision-making for sustainable development in a healthcare ecosystem to serve better the lives of citizens.

To complete the objectives of designing and implementing the core components of the healthcare industry, start with strategy and invest in complex and diversity models of frameworks into the healthcare ecosystem, especially the core infrastructure elements are including activities of the public and private services as well as innovative AI-driven solutions, AI-based Computer Vision, AI-integrated IoT technologies, Data analytics tools, Cloud services, Cybersecurity techniques, and other intelligent devices for supporting continuous operating in the smart healthcare environment.

The book will share and contribute new ideas, methodologies, technologies, approaches, models, frameworks, theories, and practices to develop, improve, and resolve the challenging issues associated with the leveraging of the emerging technologies of machine vision, AI-driven computer vision, machine learning, deep learning, AI-integrated IoT technology, data science, blockchain, AR/VR technology, cloud data, and Cybersecurity techniques in designing and implementing a smart healthcare infrastructure in the era of Industrial Revolution 4.0.

This book targets a mixed audience of students, engineers, scholars, researchers, academics, and professionals who are learning, researching, and working in the medical and healthcare industries in different environments and countries.

Happy reading!
Editors: Alex Khang, Vugar Abdullayev,
Olena Hrybiuk, Arvind K. Shukla

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The book ***Computer Vision and AI-integrated IoT Technologies in Medical Ecosystem*** is based on the design and implementation of artificial intelligence (AI), AI-driven computer vision, machine learning, deep learning, big data solutions, cloud platforms, and cybersecurity technology in the healthcare and medical ecosystem.

Preparing and designing a book outline to introduce to readers around the world is the passion and noble mission of the editorial team. To be able to make ideas a reality and this book a success, the biggest reward belongs to the efforts, experiences, enthusiasm, and trust of the contributors.

To all the reviewers with whom we have had the opportunity to collaborate and monitor their hard work remotely, we acknowledge their tremendous support and valuable comments not only for the book but also for future book projects.

We also express our deep gratitude for all advice, support, motivation, sharing, collaboration, and inspiration we received from our faculty, contributors, educators, professors, scientists, scholars, engineers, and academic colleagues.

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Editorial team: Alex Khang, Vugar Abdullayev, Olena Hrybiuk, Arvind K. Shukla

1 Application of Computer Vision (CV) in the Healthcare Ecosystem

Alex Khang, Vugar Abdullayev, Eugenia Litvinova, Svetlana Chumachenko, Abuzarova Vusala Alyar, and P. T. N. Anh

1.1 INTRODUCTION

The world we live in now is a world surrounded by technological possibilities, and this world is the result of the imaginations, beliefs and efforts of people who lived many years ago and are still living today. The current works also create the foundation for the future. One of such great ideas and results that have become a part of our daily life are artificial intelligence (AI) and AI-based technologies.

It is noted in much literature that "the idea of man wanting to create machines that can think like humans has been around for years." Concretely, the initial ideas about this have been known since the middle of the last century. In simple terms, the main content of the idea of AI is the design of technologies that are intelligent and can work independently (Rana et al., 2021).

The main role model in the idea of AI is human-robotics. In other words, the main goal of AI is the creation of intelligent machines-systems that can think like humans, and make decisions in conditions of 'inaccuracy' and 'uncertainty' like humans.

The term "artificial intelligence" was first proposed in 1956 by John McCarthy, known as "the father of artificial intelligence," at a Dartmouth conference. In fact, the roots of this term go back to the 1940s. One of the first practical works was the use of the Bombe machine, created by Alan Turing, to break German ciphers – the Enigma machine – during World War II. In particular, the success of using this machine was one of the main events for realizing the idea of AI. One of Alan Turing's contributions to AI is his idea "Can Machines Think?" It was to put forward his opinion. The idea was mentioned in his paper "Computing Machines and Intelligence." This was the paper that introduced the concept known as the Turing test to the public.

Finally, for the first time, the concept of real AI was proposed by John McCarthy in 1955, for the 1956 Dartmouth conference become a reality. Next, a new stage of AI development began. AI is a broad field that encompasses computer science, data analytics and statistics, hardware and software engineering, linguistics, neuroscience, and even philosophy and psychology. So, AI has been containing and popularizing many different concepts depending on different areas.

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AI is at the core of many so-called smart technologies today (Khang et al., 2023c). It combines many AI-based concepts and ensures their use separately and in a hybrid form.

A glossary of terms related to AI includes the following concepts:

- Machine learning (ML), deep learning (DL), and reinforcement learning (RL)
- Neural networks, evolutionary computing, chaos theory, probabilistic computing, genetic algorithms
- Natural language processing (NLP) and recommender systems
- Internet of Things (IoT)
- Computer vision (CV)

These concepts are just a small part. The concepts themselves have sub-concepts. In short, this list could go on forever. Although these concepts are technologically oriented, the services they provide in each case are related to human nature.

As a result of the joint work of various subsystems of artificial intelligence, machines can move, hear, make partial decisions, see, and make calculations just like people. As we mentioned, while AI is a very broad concept, we will look at the concept of CV, which is a part of it.

Computer vision works according to human vision. The main issue is to get the necessary information from the images. In recent times, it has been a field that has been applied more often in various fields and is the basis of many different technologies. It is one of the important factors for machine decision-making. Image processing is essential for a machine to make independent decisions, and this is accomplished by CV and its components. In general, we will consider the following sections:

1. Computer Vision – As a Concept of Robotization of Human Vision
2. Application Areas of CV Systems
3. Computer Vision Concept in Healthcare
4. Examples of CV in Healthcare: Analysis of Brain Tumors in the MATLAB Environment

1.2 COMPUTER VISION – AS A CONCEPT OF ROBOTIZATION OF HUMAN VISION

Image processing means obtaining necessary information from images and videos, as well as performing processes such as object recognition from live videos. The processes of capturing, interpreting, understanding, and processing objects in visually perceived images and videos are generally carried out. Although the concept of CV is considered a relatively new concept, its history coincides with the time when AI was put forward. So, for the first time in the 1960s, work related to this concept began to be done. CV works according to human vision. As in AI, its role model is human – the human eye (Khang & Medicine, 2023).

A person sees any object with his or her eyes, but on the other hand, the main issue falls on the brain. Thus, the brain recognizes, interprets, understands, and classifies

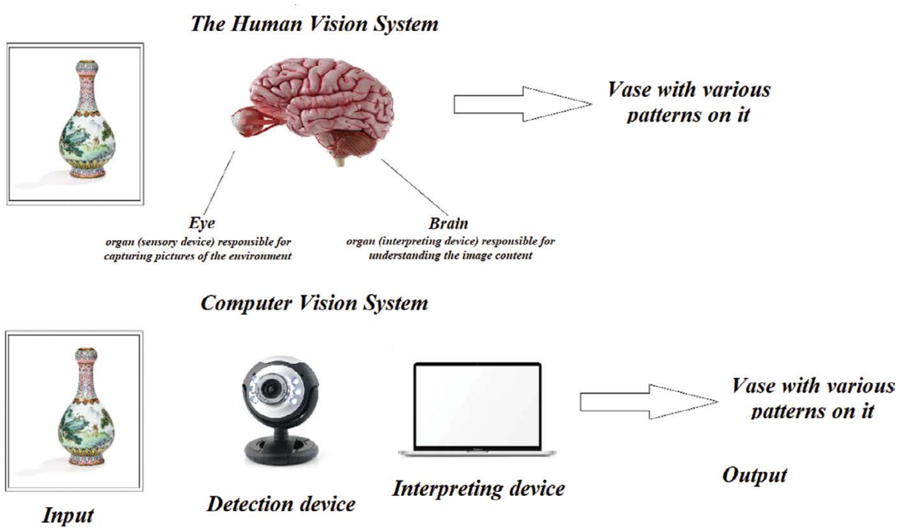

FIGURE 1.1 Common mechanisms in human vision and computer vision (Khang, 2021).

the object through signals from the eyes. It then creates and forwards ideas about that object. It can recognize and classify new objects by comparing unknown objects (for example, when a person sees an object for the first time) with other objects he or she knows and their characteristics. Considering that CV also takes a person as a role model, we can note that CV includes both components of vision and other processes; and of course, it also uses cameras, data, databases, and AI algorithms for its works as described in the human vision and CV in Figure 1.1.

1.3 COMPUTER VISION COMPONENTS

Recognition of any object through computer vision is not limited to just one principle. The problem of the object recognition process is solved by joint action. Some of the other concepts related to computer vision can be listed in the following subsections.

1.3.1 Database

Computer vision works with a lot of data. It repeatedly analyzes data to implement processes such as recognition, categorization, and interpretation of objects. It compares the data repeatedly. In this regard, it is constantly in contact with the database for the full implementation of processes. In terms of analyzing data, computer vision mainly uses two technologies: Deep learning and neural networks (Rani et al., 2022).

1.3.2 Deep Learning and Machine Learning

Deep learning is a field of ML and AI that uses artificial neural networks to mimic the activity of the human brain. The main goal is to teach computers to learn, filter, and analyze data like a human brain. Through DL, computers can perform this process. Deep learning is itself a sub-concept of ML (IBM, 2023).

According to IBM's definition, ML is a branch of AI and computer science that focuses on using data and algorithms to mimic the way humans learn, with incremental accuracy (SAS, 2023).

In particular, machine learning is preferred in modeling. ML works with structured data. Deep learning is a machine-learning subsystem that consists of a neural network with three or more layers that mimics the human brain. In terms of making accurate predictions, deep learning tries to optimize and refine the hidden layers, as shown in Table 1.1.

TABLE 1.1
Key Differences between Machine Learning and Deep Learning

Sr. No.	Differences between Machine Learning and Deep Learning	Machine Learning	Deep Learning
1.	Data dependency	Machine learning depends on large amounts of data. However, it works with few.	Deep learning is also heavily dependent on large amounts of data, as well as working with a lot of data.
2.	Human intervention	Machine learning requires more human intervention in terms of getting results.	While deep learning is difficult to build, it requires minimal human intervention after the process.
3.	Time – Duration of execution	Machine learning can be set up and run faster, but it takes a long time to produce results.	Although deep learning takes a long time to set up and get running, it is quite fast in terms of getting results.
4.	Approach to problem solving	A machine learning model breaks down a problem into sub-problems to solve it. After solving each part separately, it returns the final result. It uses a traditional algorithm like linear regression.	Deep learning takes a different approach than machine learning. It accepts inputs for a problem and outputs a result. This is due to its use of artificial neural networks.
5.	Type of data	Machine learning works with structured data.	Deep learning can work with both structured and unstructured data.
6.	Compatibility	Machine learning is suitable for solving simple or relatively complex problems.	Deep learning is suitable for solving complex problems.
7.	Conclusion comment	Interpretation of the result is easy with machine learning. Since it solves problems by dividing them into sub-problems, we can then easily understand how the problem was solved and the result was obtained.	With Deep learning, the result interpretation is complex. We can get the result faster, but it will not be so easy to understand. We can attribute this to its use of hidden layers of artificial neural networks.

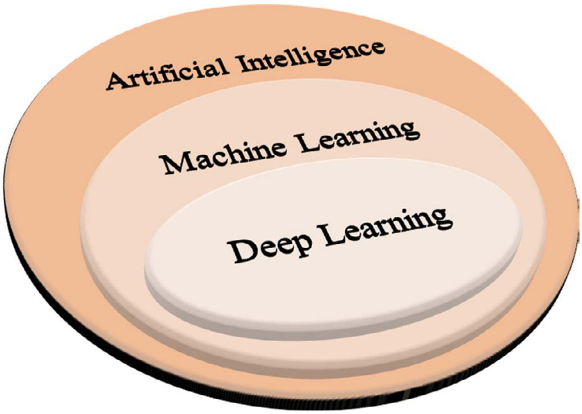

FIGURE 1.2 Dependence between artificial intelligence, machine learning, and deep learning.

We can state the dependency between artificial intelligence, machine learning, and deep learning in Figure 1.2.

1.3.3 Neural Networks

Neural networks – also called artificial neural networks – are part of machine learning. At the same time, it forms the basis of deep learning. Neural networks mimic the way neurons work in the human brain. Neural networks are a network consisting of an input layer, several hidden layers, and an output layer. There are many nodes here, and each of them is connected to the others. Each has a specific weight and limit as shown in Figure 1.3.

Here, X1 and X2 represent the inputs, W1 and W2 represent the weights, and Y represents the output. In addition, a simple neural network is shown in Figure 1.4.

Here again, *X* represents input, *W* represents weight, and *Y* represents output. In Figure 1.4, signals enter three neurons passing through *n* number of points. These

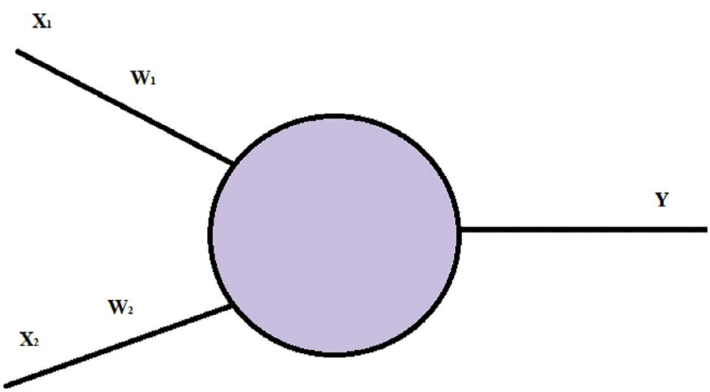

FIGURE 1.3 Single neuron model.

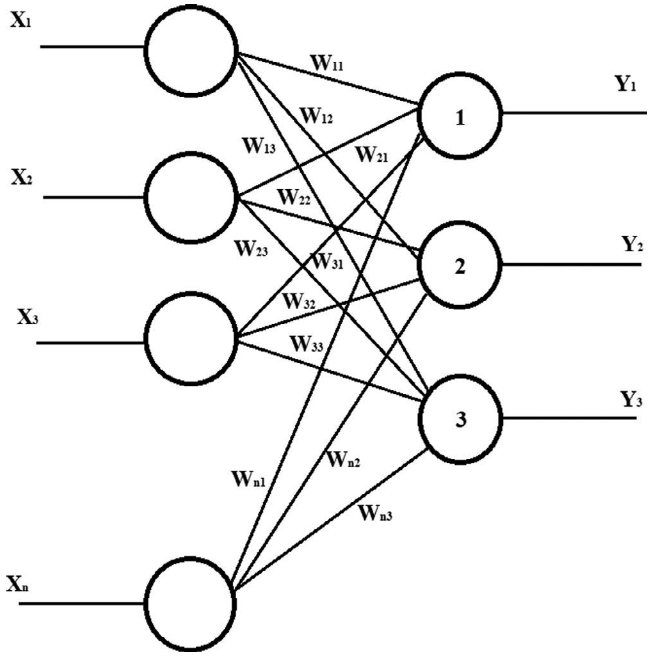

FIGURE 1.4 Simple neural network.

three neurons form a layer, and each neuron produces an output signal calculated as Equation (1.1).

$$Y_j = f\left[\sum_{i=1}^{n} x_i w_{ij}\right] j = 1\ldots3 \tag{1.1}$$

Neural networks, one of the main parts of deep learning, have a particularly active role in object recognition. They mainly analyze the incoming data and compare it with the data in the database. These processes are repeated many times until the final result is obtained.

Information is fed to the neural network through the input layer, which communicates with the hidden layers. Processing takes place through a system of weighted compounds in hidden layers. Nodes in the hidden layer combine the data from the input layer with a set of coefficients and assign appropriate weights to the inputs. These input weight products are then summarized. The sum is passed through a node's activation function, which determines the extent to which a signal is propagated through the network to affect the final output. Finally, the hidden layers are connected to the output layer, where the outputs are received (SAS, 2023). There are different types of neural networks. Among them, convolutional neural networks are used in this field.

1.3.4 Navigation Systems

Today's navigation system uses global positioning satellites (GPS) to accurately determine the location of people or cars (as well as other vehicles), compare it to the desired destination, and guide the selected route (Grady, 2009). Navigation systems are among the main systems that help computer vision systems in terms of detecting moving objects (radar systems, CCTV systems, etc.).

1.3.5 Signal processing

Signal processing, as a separate field, involves analyzing various signals and obtaining meaningful, necessary information from them. This is one of the concepts related to computer vision. There are different signals in nature, artificial and natural, that carry different information. The main challenge is to extract data from those signals. In this regard, signal processing is carried out.

1.3.6 Computer Vision Working Principle

Simply, CV works by trying to mimic the human brain's ability to recognize visual information. It uses pattern recognition algorithms to train machines on large amounts of visual data. The machine/computer then processes the input images, labels the objects in those images, and finds patterns in those objects (Chatterjee, 2022).

1.4 APPLICATION AREAS OF COMPUTER VISION SYSTEMS

With the principle of attention-grabbing operation, computer vision systems (CVS) are applied in various fields. We can mention some of the areas where CVS is most commonly applied:

1. Agriculture
2. Military
3. Industry
4. Healthcare
5. Education
6. Transportation

1.4.1 Agriculture

Agriculture has begun to be intertwined with relatively new technology. In recent times, as a result of the increase in investment in agriculture, the integration of smart technologies into agriculture has increased (Khang, 2023a,b). Agricultural technology companies are developing advanced CV and AI models for agriculture. One of the most widely used technologies powered by CV systems is drone technology. CV technology has numerous current and future applications in agriculture. Computer vision solutions in agriculture help identify crop defects and sort crops based on weight, color, size, maturity, and many other factors. When combined with the right mechanical equipment, they can save time and reduce time to market (Vaitkus, 2023).

1.4.2 Military

Computer vision is used for various purposes in the military sector. It is used for reconnaissance, autonomous weapons, UAVs, target detection, military maintenance, and training programs. However, it is quite expensive. In this respect, its complete integration into the military sector has not been possible, especially for many countries.

1.4.3 Industry

One of the areas where computer vision is most widely applied is industrial activities. Recent industrial revolutions have enabled the widespread application of technology to industry. Already smart technologies are an integral part of industry. Predictive maintenance systems use CV in inspection systems. By constantly scanning the environment, these tools minimize machine breakdowns and product deformations. If a suspected malfunction or substandard product is detected, the system alerts human personnel and allows them to take further action. In addition, CV is used by employees in packaging and quality monitoring activities (Ashtari, 2022).

1.4.4 Healthcare

One of the top sectors where computer vision is being applied is the healthcare sector. Medical image processing, disease detection, and surgical simulation are some of the applications of computer vision in healthcare (Khang et al., 2023b). We will mention in detail the application of computer vision in healthcare in the next section.

1.4.5 Education

One of the sectors where computer vision is being applied is the field of education. The main issue here is controlling students by their enthusiasm for the lesson, and other factors will be studied further. In addition, the assessment process is easier and more qualitative with the help of computer vision. In short, each student's performance in the classroom can be easily monitored with the help of CV system. Still, the integration of CV into education is relatively controversial.

1.4.6 Transportation

CV is extremely important for the future of the transportation sector. CV has a major role in autonomous vehicles, parking management, and traffic management (Hajimahmud et al., 2022). In general, CV is applied in the areas of transportation sector: Road traffic safety, data collection, traffic and transport system modeling, traffic flow parameter estimation, etc.

1.5 COMPUTER VISION CONCEPT IN HEALTHCARE

CV has an irreplaceable role in fields such as military and transport, is also an indispensable technology in the health sector such as Detection, comparison, classification, and interpretation of various diseases are carried out using the dataset. So, in this case, ML, DL algorithms, and AI networks are used as mentioned in Khang et al. (2023c). The number of datasets in healthcare is overwhelming, this information consists of numbers, words, and pictures. According to researchers, image data makes up about 90 percent of all healthcare data. This amount of image data is one of the main reasons for the application of computer vision systems.

CV can improve the quality of services offered to patients and reduce the time it takes to make treatment decisions, which will improve overall efficiency in healthcare. In short, the technology takes care of itself, and human workers can focus on more complex tasks. The proper use of CV in medicine will help reduce the time spent on unnecessary diagnostic procedures and provide the healthcare professional with the tools to make more accurate diagnoses and prescribe more effective treatments (Skryl, 2020). Some of them are as in Table 1.2 (EPAM Startups & SMBs, 2023):

TABLE 1.2
Computer Vision Applications and Their Brief Information

Sr. No.	Computer Vision Applications	Brief Information
1.	DICOM image analysis	Digital Imaging and Communications in Medicine (DICOM) is the de facto standard that defines the rules that enable the exchange of medical images (X-Ray, MRI, CT) and related data between imaging equipment from different vendors, computers, and hospitals. The DICOM format provides a compliant means of health information exchange (HIE) standards for the transfer of health-related data between enterprises and HL7, a messaging standard that enables data exchange for clinical applications (Khang et al., 2024).
2.	Detection of anomalies in MRI, CT, and X-ray examinations	MRI, CT, and X-ray are all medical imaging tools. Although they perform similar tasks, all three have their own characteristics. CV technologies are widely used for the analysis of medical images obtained from them.
3.	Diagnostic help	CV systems are indispensable in terms of data analysis to obtain diagnostic results. Correct and timely analysis of data is important for making the correct diagnosis.
4.	Surgical assistance and prevention of accidental stoppage of surgical instruments	CV can help surgeons and other medical professionals prepare for operations, as well as monitor and inspect surgical instruments before and after surgery.

(*Continued*)

TABLE 1.2 (*Continued*)
Computer Vision Applications and Their Brief Information

Sr. No.	Computer Vision Applications	Brief Information
5.	Retinal scanning and early detection of structural changes	Analysis of data obtained from EOG signals, when use case of CV for detection of changes.
6.	Identification and analysis of new or recurrent skin abnormalities	CV is irreplaceable in terms of tracking (control and monitoring) skin changes, especially in skin cancer. Thus, changes in the patient's stable condition are also controlled.
7.	Remote monitoring and patient care	With CV, doctors can be continuously interested in patients who are treated at home and can monitor changes in their condition. In general, the patient's daily activities, medication intake, nutrition, physical activity, etc. can be monitored.
8.	Tumor detection	CV systems are used to detect tumors (malignant or benign) in different parts of the body.
9.	Hygiene examination of the hospital	By allowing automated analysis of patient rooms, computer vision can help detect dirt, dust, and other forms of contamination that may be harmful to patients and staff (Boesch et al., 2023).
10	Smart medical training	An example of application in medical sector, CV is used in simulating the training process for young surgeons..
11	Prevention of disease and infections	In general, CV can detect various diseases in healthcare ecosystem. It has an important role in the process of their prevention of diseases from analysis to detection.
12	Early detection of the disease	With CV, it is possible to detect various diseases in a quick time interval by monitoring the changes in the condition of patients.

1.6 EXAMPLES OF COMPUTER VISION IN HEALTHCARE

Case study is an analysis of brain tumors in the MATLAB environment, let's look at a simple example related to the detection of a tumor in the brain in the MATLAB environment. The MRI images used in the examples below were obtained from sites (MRI, 2023) and (Tumor, 2023), programs are written using Ris (2020) and BTD (2023) as shown in Figure 1.5.

```
>> clc
close all
clear all
[I,path]=uigetfile('*.jpg','select a input image');
str=strcat(path,I);
MRI=imread(str);
figure;
imshow(MRI);
title('Input image');
```

FIGURE 1.5 MATLAB code to input image data.

With Imshow, the image read through Imread will be displayed as in Figure 1.6.

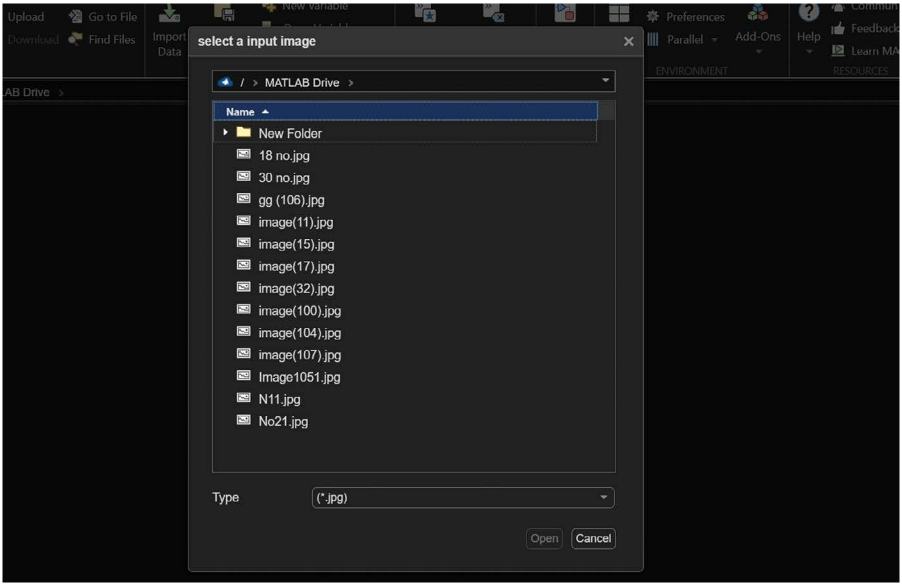

FIGURE 1.6 Dialogue window where the images are located in directory.

The images here are each an MRI image of the brain as in Figure 1.7.

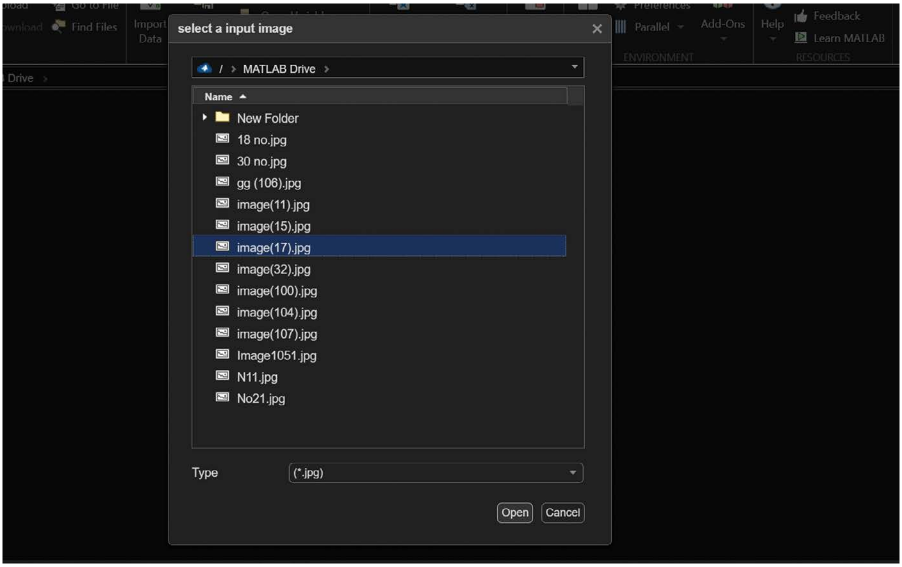

FIGURE 1.7 Image (17).jpg is selected as input data.

Run program and output as shown in Figure 1.8.

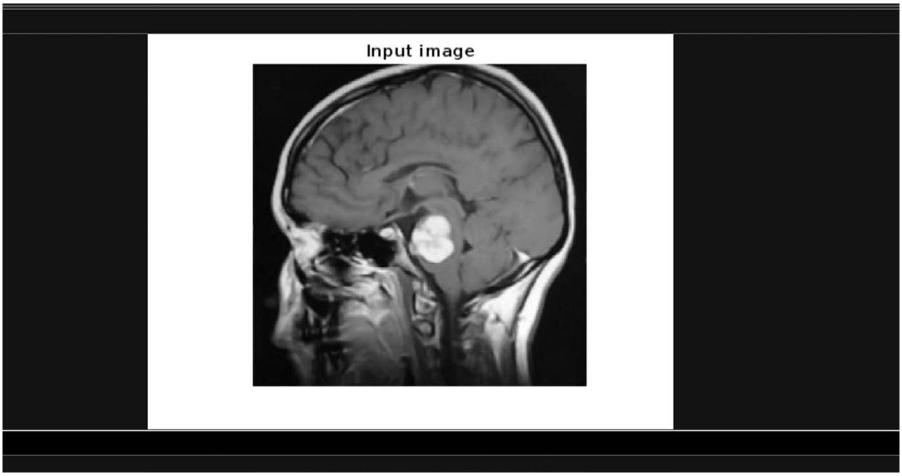

FIGURE 1.8 Input data.

Add more lines of code and describe only the tumor in the image which is shown in Figure 1.9.

```
>> clc
close all
clear all
[I,path]=uigetfile('*.jpg','select a input image');
str=strcat(path,I);
MRI=imread(str);
figure;
imshow(MRI);
title('Input image');
bw=im2bw(MRI,0.7);
label=bwlabel(bw);
stats=regionprops(label,'Solidity','Area');
density=[stats.Solidity];
area=[stats.Area];
high_dense_area=density>0.3;
max_area=max(area(high_dense_area));
tumor_label=find(area==max_area);
tumor=ismember(label,tumor_label);
if max_area>100
   figure;
   imshow(tumor)
   title('Tumor alone');
else
    h = msgbox('No Tumor!!','status');
    %disp('no tumor');
    return;
end
```

FIGURE 1.9 MATLAB code to describe only the tumor in the image.

Run MATLAB code to describe only the tumor in the image as shown in Figure 1.10.

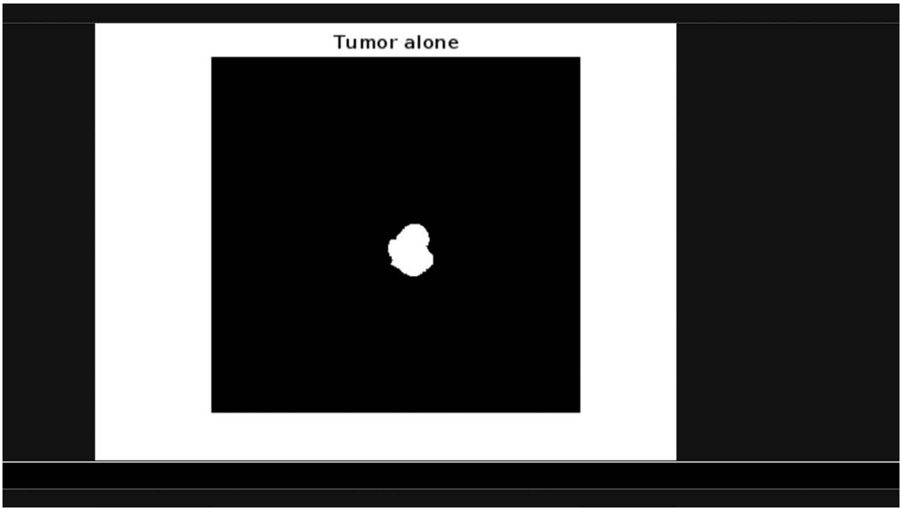

FIGURE 1.10 A description of the tumor alone.

Add more lines of code tumor detection with a defined boundary, which is shown in Figure 1.11.

```
>> clc
close all
clear all
[I,path]=uigetfile('*.jpg','select a input image');
str=strcat(path,I);
MRI=imread(str);
figure;
imshow(MRI);
title('Input image');
bw=im2bw(MRI,0.7);
label=bwlabel(bw);
stats=regionprops(label,'Solidity','Area');
density=[stats.Solidity];
area=[stats.Area];
high_dense_area=density>0.3;
max_area=max(area(high_dense_area));
tumor_label=find(area==max_area);
tumor=ismember(label,tumor_label);

[B,L] = bwboundaries(tumor,'noholes');
imshow(MRI,[])
hold on
for k = 1:length(B)
   boundary = B{k};
   plot(boundary(:,2), boundary(:,1), 'x', 'LineWidth', 3)
end
title('Detected Tumor');
hold off;
```

FIGURE 1.11 MATLAB code for tumor detection with a defined boundary.

Run MATLAB code to describe only the tumor in the image as shown in Figure 1.12.

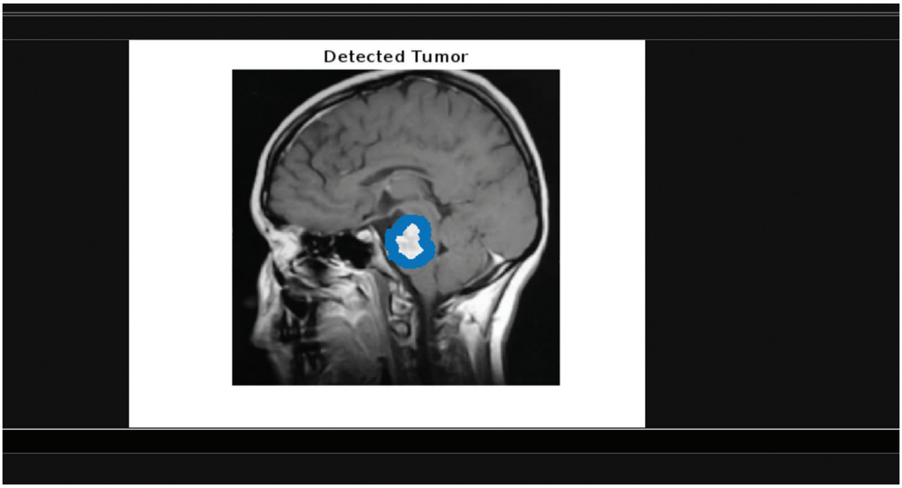

FIGURE 1.12 Image of tumor detection.

If there is no Tumor in Figure 1.12, “No Tumor!!” Below is the code about opening the dialog window as Figure 1.13.

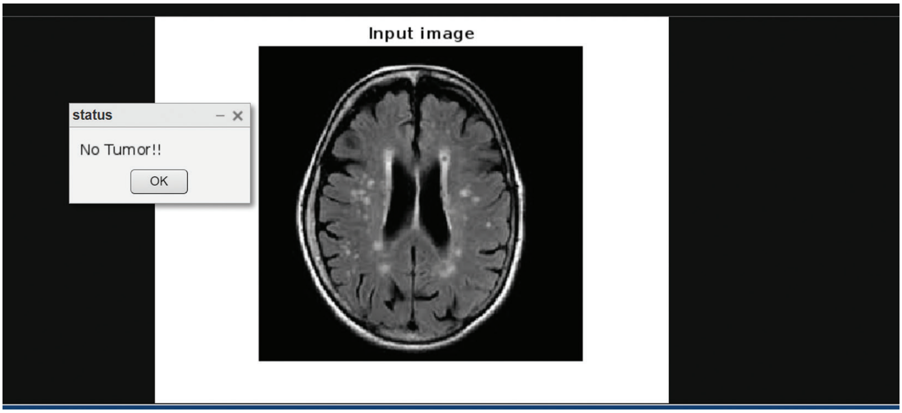

FIGURE 1.13 “No Tumor” result.

1.7 CONCLUSION

Artificial intelligence systems have wide capabilities, and their main technologies are applied in individual and hybrid form in many fields. Today and in the future, AI-based technologies are indispensable. One of the important areas for the future of any society is healthcare. Investments in healthcare always pay off. With the application of technologies in healthcare, new opportunities are obtained, service quality is further improved, decision-making time is reduced, and efficiency is increased (Anh et al., 2024).

The majority of information in healthcare is images, and the correct analysis of these images helps to increase the possibilities we have listed above. In this regard, computer vision, which is a branch of artificial intelligence, has been applied in recent times (Khang et al., 2022). The following results were obtained from this chapter:

1. The healthcare sector continues to grow and evolve with technology. Priority is given to timely and quality service.
2. Most of the information in healthcare is descriptive information. Better service can be provided by analyzing this data.
3. The application of computer vision in healthcare is expanding.
4. CV uses ML, DL algorithms, and artificial neural networks for image analysis, new disease detection, comparison, and interpretation.
5. CV is based on DL and convolutional neural networks.
6. CV is applied in various parts of healthcare: Tumor detection, diagnostic assistance, surgical assistance, etc.
7. CV will continue to be increasingly used in healthcare as shown in Figure 1.1.

REFERENCES

Anh P. T. N., Vladimir Hahanov, Triwiyanto, Ragimova Nazila Ali, Rashad İsmibeyli, Vugar Abdullayev, Abuzarova Vusala Alyar. 2024. "AI Models for Disease Diagnosis and Prediction of Heart Disease with Artificial Neural Networks," *Computer Vision and AI-integrated IoT Technologies in Medical Ecosystem* (1st Ed.). CRC Press. https://doi.org/10.1201/9781003429609-9

Ashtari H. 2022. What Is Computer Vision? Meaning, Examples, and Applications. Retrieved from https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-computer-vision/

Boesch G. 2023. Top 19 Applications of Deep Learning and Computer Vision In Healthcare. Retrieved from https://viso.ai/applications/computer-vision-in-healthcare/.

BTD 2023. Brain Tumor Detection Using MATLAB – Image Processing + GUI Step by Step. Retrieved from https://youtu.be/UeFRo7uALhM

Chatterjee M. Nov 21, 2022. What is Computer Vision? Know Computer Vision Basic to Advanced & How Does It Work? Retrieved from https://www.mygreatlearning.com/blog/what-is-computer-vision-the-basics

EPAM Startups & SMBs 2023. Computer Vision in Healthcare: A Secret Guide for Winners. Retrieved from https://anywhere.epam.com/business/computer-vision-in-the-medical-field

Grady J. P., Spring M. B., Rotondi A. J. 2009. "Designing Medical Research Web Sites," *Handbook of Research on Information Technology Management and Clinical Data Administration in Healthcare*, p. 18. IGI Global. https://doi.org/10.4018/978-1-60566-356-2.ch053

Hajimahmud V. A., Khang A., Hahanov V., Litvinova E, Chumachenko S., Alyar V. A. 2022. "Autonomous Robots for Smart City: Closer to Augmented Humanity," *AI-Centric Smart City Ecosystems: Technologies, Design and Implementation* (1st Ed.), 7 (12). CRC Press. https://doi.org/10.1201/9781003252542-7

IBM Machine Learning 2023. What Is Machine Learning? Retrieved from https://www.ibm.com/topics/machine-learning.

Khang A. 2021. "Material4Studies," *Material of Computer Science, Artificial Intelligence, Data Science, IoT, Blockchain, Cloud, Metaverse, Cybersecurity for Studies*. Retrieved from https://www.researchgate.net/publication/370156102_Material4Studies

Khang A. 2023a. *Advanced Technologies and AI-equipped IoT Applications in High-Tech Agriculture* (1st Ed.). IGI Global Press. https://doi.org/10.4018/978-1-6684-9231-4

Khang A. 2023b. *AI and IoT-Based Technologies for Precision Medicine* (1st Ed.). IGI Global Press. ISBN: 9798369308769. https://doi.org/10.4018/979-8-3693-0876-9

Khang A., Abdullayev V., Hrybiuk O., Shukla A. K. 2024. *Computer Vision and AI-integrated IoT Technologies in Medical Ecosystem*. CRC Press. https://doi.org/10.1201/978-1-0034-2960-9

Khang A., Gupta S. K., Hajimahmud V. A., Babasaheb J., Morris G. 2023a. *AI-centric Modelling and Analytics: Concepts, Designs, Technologies, and Applications* (1 Ed.). CRC Press. https://doi.org/10.1201/9781003400110

Khang A., Gupta S. K., Shah V., Misra A. (Eds.) 2023b. *AI-aided IoT Technologies and Applications in the Smart Business and Production*. CRC Press. https://doi.org/10.1201/9781003392224

Khang A., Ragimova N. A., Hajimahmud V. A., Alyar V. A. 2022. "Advanced Technologies and Data Management in the Smart Healthcare System," *AI-centric Smart City Ecosystems: Technologies, Design and Implementation* (1st Ed.), 16 (10). CRC Press. https://doi.org/10.1201/9781003252542-16

Khang A., Rana G., Tailor R. K., Hajimahmud V. A. (Eds.). 2023c. *Data-centric AI Solutions and Emerging Technologies in the Healthcare Ecosystem*. CRC Press. https://doi.org/10.1201/9781003356189

MRI 2023. Retrieved from https://www.kaggle.com/datasets/sartajbhuvaji/brain-tumor-classification-mri.

Rana G., Khang A., Sharma R., Goel A. K., Dubey A. K. (Eds.) 2021. *Reinventing Manufacturing and Business Processes Through Artificial Intelligence*. CRC Press. https://doi.org/10.1201/9781003145011

Rani S., Bhambri P., Kataria A., Khang A. 2022. "Smart City Ecosystem: Concept, Sustainability, Design Principles and Technologies," *AI-centric Smart City Ecosystems: Technologies, Design and Implementation* (1st Ed.), 1 (20). CRC Press. https://doi.org/10.1201/9781003252542-1

Ris 2020. Brain Tumor Segmentation in MATLAB. Thesis Implementation Sample – Brain Tumor Segmentation in MATLAB. Retrieved from https://www.ris-ai.com/brain-tumor-segmentation-in-matlab.

SAS 2023. Artificial Neural Networks, What They Are & Why They Matter. Retrieved from https://www.sas.com/en_us/insights/analytics/neural-networks.html.

Skryl H. 2020. Computer Vision in Healthcare Applications. Retrieved from https://vilmate.com/blog/computer-vision-in-healthcare-applications/.

Tumor 2023. Brain MRI Images for Brain Tumor Detection. Retrieved from https://www.kaggle.com/datasets/navoneel/brain-mri-images-for-brain-tumor-detection

Vaitkus A. 2023. Computer Vision in Agriculture: Introduction to Smart Farming. Retrieved from https://easyflow.tech/computer-vision-in-agriculture-introduction-to-smart-farming.

2 Artificial Intelligence (AI)-Assisted Computer Vision (CV) in Healthcare Systems

Wasswa Shafik, Ahmad Fathan Hidayatullah, Kassim Kalinaki, and Muhammad Muzamil Aslam

2.1 INTRODUCTION

The growth of AI-assisted computer vision (AACV) in healthcare systems has the potential to enhance healthcare quality and delivery, particularly in developing countries where healthcare infrastructure and access to care are limited (Haque & Rahman, 2023). These technologies can be deployed in remote areas, where there is a shortage of healthcare professionals, to offer rapid and exact diagnoses and treatments, leading to improved health outcomes (Gimeno-García et al., 2023).

In addition, since medical data tend to be massive, analyzing these enormous amounts of healthcare data to identify trends and patterns that could inform public health policies and interventions is possible. This can improve disease surveillance, outbreak detection, and management, particularly in regions with prevalent infectious diseases (Deriba et al., 2023; Zhao et al., 2022).

As technology continues to advance, there is a need for healthcare professionals to be trained in AI-aided CV, particularly in interpreting and validating algorithm outputs. This will ensure that healthcare providers have the necessary skills to effectively integrate the technology into their practice and deliver high-quality care (Bhattamisra et al., 2023).

In addition, AACV's potential applications and benefits in healthcare are expanding rapidly. For example, AACV can improve cancer detection accuracy, allowing for earlier diagnoses and more effective treatments. It can also help healthcare providers identify and manage chronic diseases, such as diabetes, by analyzing patient data and providing personalized treatment recommendations (Alaziz et al., 2023; Tao et al., n.d.).

AACV can be used to develop predictive models that identify potential healthcare issues before they become critical, such as outbreaks of infectious diseases or adverse drug reactions. This can help healthcare providers be more proactive in their interventions and reduce the risk of widespread illness or harm (Shen et al., 2023). However, despite the potential benefits, AACV also presents several challenges that

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must be addressed. For example, ensuring the accuracy and reliability of the algorithms is crucial to prevent unintended consequences, and data privacy and security must be safeguarded to protect sensitive medical data (Mehta et al., 2023).

Moreover, integrating AACV into healthcare systems can help address the challenges faced by the healthcare industry, such as the shortage of healthcare professionals and the increasing demand for healthcare services due to population growth and aging (Mehta et al., 2023). By automating tasks that healthcare professionals traditionally perform, AACV can free up time for healthcare providers to focus on more complex tasks that require human expertise, such as patient communication and care coordination (Shafik & Tufail, 2023).

However, one of the primary concerns is the potential for bias in the algorithms used for medical imaging and diagnosis, which could result in unequal healthcare outcomes for different patient populations.

There is also a need for ethical and regulatory frameworks to guide the advance and deployment of AI-aided CV technologies in healthcare to ensure patient safety and privacy (Tenajas et al., 2023; Yao et al., 2021). Therefore, AACV is an innovative technology that has the potential to enhance healthcare systems and improve patient care. From medical imaging to surgical procedures to patient monitoring, AACV can provide accurate and efficient diagnoses and treatments, reducing healthcare costs and refining patient outcomes.

However, algorithm accuracy and reliability challenges, data privacy and security, and ethical and regulatory considerations must be addressed to fully realize this technology's potential (Dhaliwal & Walsh, 2023). Nevertheless, with continued innovation and collaboration between healthcare professionals, technology experts, and policymakers, AACV has the probability of transforming healthcare systems and improving healthcare outcomes for all.

2.2 ARTIFICIAL INTELLIGENCE AND COMPUTER VISION OVERVIEW IN THE HEALTHCARE SYSTEM

Together with their application, AI and CV rapidly transform the healthcare sector. AI refers to developing artificial systems that can perform tasks typically requiring human intelligence. It involves using algorithms and statistical models that enable machines to analyze data, identify patterns, and make predictions or recommendations.

While AI is inspired by human intelligence, it is not merely a simulation of it but rather a new form of intelligence that has the potential to revolutionize many aspects of our lives, like decision-making, natural language processing, and speech recognition (Zhang et al., 2023).

Conversely, CV is a subsection of AI that enables artificial systems to interpret and analyze images and video data. AACV in healthcare has numerous applications, from improving medical imaging to assisting in surgical procedures to analyzing real-time patient data to provide personalized treatment recommendations as shown in Figure 2.1.

However, integrating AACV into healthcare systems is not without its challenges. One of the primary concerns is the potential for bias in the algorithms used for

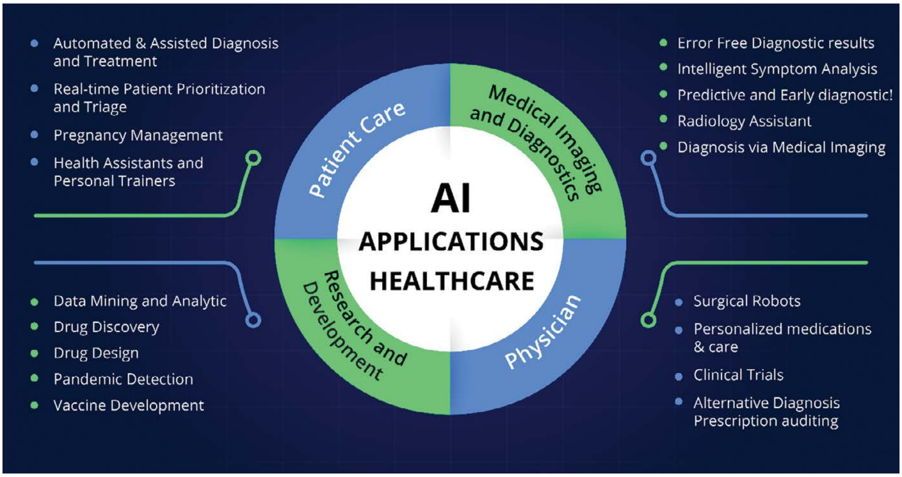

FIGURE 2.1 Application of artificial intelligence in healthcare.

medical imaging and diagnosis, which could result in unequal healthcare outcomes for different patient populations (Shafik & Tufail, 2023; Xu et al., 2023).

There is also a need for ethical and regulatory frameworks to guide the development and deployment of AACV technologies in healthcare to ensure patient safety and privacy. Despite these challenges, AACV's potential applications and benefits in healthcare are immense (Kang et al., 2023). AACV can significantly enhance healthcare delivery and quality by providing accurate and efficient diagnoses and treatments, improving surgical procedures, enabling proactive patient monitoring, and informing public health policies and interventions.

This chapter mainly presents a general overview of AACV in the healthcare system. This involves the presentation of recent developments of AI and CV in healthcare in the quest to enhance the medical field since it is an entire sector that helps all sorts of people at different medical levels. Several applications are demonstrated that improve healthcare systems. The challenges influencing the AACV in healthcare systems are detailed and discussed. The chapter further discusses the area's future trends, since most people are starting to accept its power and how effectively it executes medical tasks for the patients at different stages of the medical requirement (Rana et al., 2021).

The rest of the chapter is arranged into seven sections. Section 2.3 presents the related literature on AACV in healthcare. Section 2.4 details the application as far as healthcare systems are concerned. Section 2.5 presents the challenges and limitations of AACV in health, and some practical solutions are shown to help stakeholders in the policy, development, and implementation.

Section 2.6 entails the seven future trends of AI-assisted CV for healthcare systems, including integration of AACV with electronic health records (EHRs), use of AACV for drug discovery and development, increased use of AACV in telemedicine, development of more advanced AI algorithms for medical imaging, development of more personalized treatment plans, adoption of AACV in developing countries, and a collaboration between healthcare providers and technology companies. Lastly, the conclusion is presented in Section 2.7.

2.3 RELATED LITERATURE

AACVs offer enormous opportunities to enhance various aspects of healthcare systems, including diagnosis, treatment, and patient care. Integrating AI and CV in healthcare systems can provide accurate and timely diagnoses, reduce medical errors, improve patient outcomes, and streamline medical processes (Khanh & Khang, 2021).

Numerous studies have applied and investigated the utilization of AI and CV in the healthcare domain. AI and CV have been assisted in identifying various diseases, such as in detecting prostate cancer, brain tumor cells (Srinivas et al., 2022), breast cancer (Jasti et al., 2022), skin cancer (Hoang et al., 2022), COVID-19–infected lungs (Meng et al., 2022; Punn & Agarwal, 2022), and dental anatomy.

Due to the recent surge in interest in machine learning (ML) and deep learning (DL), these approaches have become critical in healthcare systems. Some studies have utilized traditional ML techniques, such as Naïve Bayes, support vector machine (SVM), k-nearest neighbor (KNN), and random forest (RF). In Win et al. (2020), a computer-assisted cervical cancer screening system was developed. Bag ensemble classifiers were used, which combined the findings of five different classifiers: linear discriminant (LD), SVM, k-nearest neighbor (KNN), boosted trees, and bagged trees.

Jusman et al. (2021) applied KNN and SVM to classify dental caries-level images with gray-level co-occurrence matrix (GLCM) features. A study by Balaji et al., (2020) developed a novel technique incorporating dynamic graph cut-based segmentation and a Naïve Bayes classifier to identify skin lesions. Their proposed technique outperformed the other methods, such as the simple ABCD rule and SVM.

DL is becoming crucial in implementing AI applications (LeCun et al., 2015). As DL techniques have become more prevalent, they have been combined and compared to traditional ML techniques. Li et al. (2019) presented a new model for cervical histopathology image classification. Their study proposed multi-layer hidden conditional random fields (MHCRFs) and applied linear SVMs, Radial Basis Function Support Vector Machines (RBF-SVMs), artificial neural networks (ANNs), and RFs in the feature extraction process.

Punn and Agarwal (2022) presented CHSNet (COVID-19 hierarchical segmentation network), a DL model using CT medical imaging to identify COVID-19–infected lung regions via hierarchical semantic segmentation. Kumar et al. (2022) performed classification for lung and colon cancer using histopathological image datasets. They utilized several classifiers, such as gradient boosting (GB), SVM-RBF, multi-layer perceptron (MLP), and RF. Moreover, they compared handcrafted and deep CNN features. Their experiments showed that the DenseNet-121 with RF classifier achieved the best performance.

Current studies have leveraged transfer learning (TL) techniques to CV. TL is widely used in CV because it can create precise models more efficiently (Rawat & Wang, 2017). In Srinivas et al. (2022), TL was applied to predict brain tumor cells automatically. Their study compared the performance of VGG-16, ResNet-50, and

Inception version 3 convolutional neural network (CNN) models by presenting a two-step TL identification model for COVID-19 medical images (Meng et al., 2022).

They employed the Vision Transformer (ViT) pre-training model to extract general features from heterogeneous data before learning medical features from enormous homogenous data. Hoang et al. (2022) developed an automated DL classification system to identify skin lesion types. In addition, a novel segmentation method was proposed to segment the skin image. A two-dimensional wide of ShuffleNet network is implemented afterward to classify the segmented skin image. Ali et al., (2022) utilized TL for multi-class skin cancer classification. In their study, EfficientNets B0–B7 were trained on the HAM10000 dataset through transfer learning on ImageNet weights and CNN fine-tuning.

2.4 APPLICATION OF AI-ASSISTED COMPUTER VISION IN MEDICAL ASPECTS

The healthcare sector was one of the first to see CV's enormous potential and the CNNs underpinning the technology. Utilizing the capabilities of AI and DL in several scenarios forms the basis of CV applications in the medical industry, such as diagnostic assistance, blood cell calculation, patient care, and remote monitoring; some sampled applications are presented in Figure 2.2.

FIGURE 2.2 Sampled computer vision application in healthcare. (Source: https://10xds.com/.)

2.4.1 Computer-Aided Diagnosis (CAD)

Imaging manual classification is not easy; it is time-consuming and challenging. This task has several chances of human error and inside changes. In radiology, CAD is considered a major research topic because it assists doctors in diagnosing diseases to a higher degree and reduces cost and time (Huang et al., 2022).

For initial-stage cancer diagnosis, CAD is considered a more efficient method with X-rays, CT, and MRI, among others. CAD is known as an effective intermediary between radiologists and input images. CAD output is not the result, they are only used as reference with further testing required. The CAD system is considered more reliable and efficient than other traditional radiology methods, and its essential parameters are total detection rate, specificity, and sensitivity (Khang et al., 2023a).

2.4.2 AI Techniques for Cancer Classification and Detection

AI techniques are methods used to create and develop computer software. AI software can mimic human perception. For AI to be used for analysis or problem-solving and to classify and identify things, input is typically needed. The SVM neural network, fuzzy models, ANN, and (KNN) are only a few of the AI techniques discussed in this study (Ramnarine, 2021).

A collection of connected disorders is cooperatively called cancer. Multiple body tissues begin to divide repeatedly and spread among cancer cells of all kinds. There are trillions of cells in the human body, which means that cancer can develop practically everywhere.

As the human body requires new tissues, human tissues typically develop and divide to create those tissues. Cells die and are replaced by new ones when they get old or damaged (Shafana & Senthilselvi, 2021). Cancer, on the other hand, develops in an unorganized manner. As cells become more aberrant, new cells emerge when unnecessary, and older or dead cells persist when they should die. These excess cells can continue to divide indefinitely and may result in tumor-like growth (Aslam et al., 2020).

2.4.2.1 Cancer Classification

AI algorithms have proved to help detect and classify different types of cancer. However, as technology progresses, these techniques may experience fluctuations over time. This is particularly true when considering the use of AI in designing architecture, as certain parameters, such as the number of nodes in hidden layers, the number of layers, network type, and activation function between layers may need to be adjusted to achieve optimal results (Nassif et al., 2022).

Researchers have developed generalization networks to address these challenges, which can work with various data types to reduce performance errors. In addition, these networks are designed to adapt to changes in data and parameter settings, allowing them to maintain consistent performance over time (Park et al., 2013). Inclusively, the use of AI in cancer detection and classification holds great promise for improving patient outcomes. However, ongoing research and development are needed to ensure that these techniques continue evolving and improving as new technologies and data become available (Khang et al., 2023b).

2.4.2.2 Breast Cancer (BC)

BC is a type of tumor that forms in breast tissues. It spreads easily to surrounding body parts. The disease mainly occurs in females but in some cases also in males. With the advancement of technology in the examination, taking an interest in CV and computational techniques to help diagnose and detect breast cancer among various cancers is the mammography technique (Koh et al., 2022). This specific mammography technique is an effective and simple tool for diagnosing breast cancer at the initial stage. In additional, Dr. William H. Walberg offered Wisconsin Breast Cancer data (WBCD) source and various techniques applied by researchers to diagnose WBCD, classify and detect breast cancer that has been applied in several research papers (Nassif et al., 2022; Park et al., 2013).

2.4.3 Neural Networks

Various neural networks use unsupervised and supervised learning techniques to classify, detect, and predict BC throughout the year. Types of neural networks are Supervised, Unsupervised, Adaptive neuro fuzzy inference system (ANFIS), and Fuzzy Logic (FL) Techniques. One well-known supervised technique (Koh et al., 2022) is MLP. It uses various training methods like GD, back propagation, Bayesian regulation, and gradient techniques. Huang et al. (2022) used MLP, while Saeedi et al. (2023) studied an unsupervised technique, the authors studied the ANFIS technique with a learning algorithm and gained high accuracy. Shafana & Senthilselvi (2021) applied homogeneous fuzzy-based rule generation and different rule mean values. Jung et al. (2017) studied fuzzy logic with different degrees but for the same objective.

2.4.3.1 Lung Cancer

Some AI classifier techniques for diagnosing BC include K-means algorithm and SVM supporting X-ray, CT, MRI, and sputum cytology. These techniques are usually time-consuming and expensive. Techniques such as MRI are costly and diagnose lung cancer with quality results. Algorithms used for lung cancer are neural networks, ANFIS, SVM, etc. When abnormal tissues develop out of control in one or both lungs, it is lung cancer (Huang et al., 2022).

Generally, the atypical cells split quickly to create tumors rather than develop into healthy lung cells (Keane & Topol, 2018). Non-small- and small-cell lung cancer are typically the two main forms of lung cancer. These tumors are determined by how tissues look under a microscope. Compared to small-cell lung cancer, non–small-cell lung cancer is more common. The sort of cancer that most frequently results in a very high fatality rate is probably lung cancer.

Early detection and prediction are the best methods for preventing lung cancer. The structure of cancer tissues, in which nearly all cells overlap, makes early detection of lung cancer a challenging problem (Ramnarine, 2021). Effective early detection of lung cancer is essential and a critical component in image processing.

2.4.3.2 Brain Cancer

The brain and spinal cord are components of the central nervous system. The most common cause of cancer-related death is likely a brain tumor. Gliomas and meningiomas are other names for brain tumors. Brain cancer and tumors that begin in the brain are two major categories of brain tumors. Cancer cells can invade and spread in the brain and spinal cord but seldom disseminate to other body areas. The more typical kind is a secondary brain tumor (Anaya-Isaza et al., 2023). It travels to the brain after starting in another area of the body, such as the lung or breast. Brain cancer is probably curable and treated if found in its early stages.

Brain tumors can spread and result in death if left untreated. Different technologies are available to obtain human brain images, such as MRIs, CT scans, and X-rays. These technologies are useful for the diagnosis of brain tumors. Some of them are expensive and time-consuming but useful for better results. Researchers use some commonly used algorithms, like ANN, which uses supervised and unsupervised learning, ANFIS, FL, KNN, and SVM methods (Khang et al., 2023c).

2.4.4 Merits of Computer Vision Applications in Healthcare

The healthcare sector is one of the critical benefactors of the rapid development of computer vision technology, as noted previously in the chapter. Numerous medical specialties have benefited from using computer vision in healthcare, and thousands of lives have been saved because of better diagnoses, early identification of health problems, and better treatment strategies. CV helped to save lives and enhance the patient experience (Jung et al., 2017; Ker et al., 2017).

2.4.4.1 Radiology

Radiology is the oldest medical technology to gain CV-based applications, radiologist believes in DICOM imaging data gained from different sources, which became useful for different purposes. These include MRI scans, CT, a computer-assisted X-ray inspection, diagnosis of bone fracture, treatment results for long periods and change detection, and initial status of new tissue formation containing tumors (Anaya-Isaza et al., 2023).

2.4.4.2 Orthopedics

CV is a valuable tool in orthopedics, enabling improved utilization and enhancing the overall range of preoperative, intraoperative, and postoperative activities. The scope of AI, DL, and CV in orthopedics includes intraoperative navigation and surgery planning, MRI-based arthroplasty planning, MRI segmentation, and detection using CT, X-rays, and 2D and 3D imaging. Additionally, robotic surgery planning is essential to this field (Zhou et al., 2020).

By incorporating CV into orthopedic practices, surgeons can benefit from improved accuracy, efficiency, and overall patient outcomes. For instance, the use of CV in preoperative planning can lead to more precise surgical procedures, and in the case of postoperative care, CV can aid in detecting complications such as infections, bone fractures, and implant misalignment. With the advancements in AI algorithms, CV technology can continue to enhance orthopedic practices, improving surgical outcomes and reducing the likelihood of complications.

2.4.4.3 Cardiology

In various aspects of work, CV assists the staff and cardiologists in their work, such as approximation of blood loss during surgeries, aiding in the identification of abnormal heart development and the tracking of the development of congenital heart disorders, and helping to keep an eye on the blood flow in arteries during surgeries (Al-shamasneh & Obaidellah, 2017).

2.4.4.4 Ophthalmology

CV technology has proved to be an effective tool in the early detection of eye diseases in children and clinics for various objectives. These include preoperative planning, retina scans, subsequent analysis, and the initial stage detection of eye development anomalies. Implementing CV in eye disease diagnosis can lead to earlier detection and treatment, improving patient outcomes (Shreve et al., 2022). Moreover, using CV technology in preoperative planning can assist surgeons in developing more accurate surgical plans and improve surgical outcomes.

The potential of CV in eye care is immense and has already shown promising results in enhancing the detection and treatment of various eye diseases, making it a valuable tool in the field of ophthalmology. CV is also helpful in detecting eye diseases in the early stage in children. It is also useful in clinics for various objectives, such as pre-operative planning, retina scans and subsequent analysis, and initial-stage discovery of eye development anomalies.

2.4.4.5 Dermatology

CV is best known for dermatologists, specifically in skin cancer treatment and diagnosis. With part of the body, doctors get images or videos for observations. CV is useful in dermatology, such as detecting initial signs of skin diseases, scanning skin resolution in high resolution and monitoring skin disease growth, and incrementing personal skincare treatment based on skin type and sensitivity (Al-shamasneh & Obaidellah, 2017).

2.5 CHALLENGES AND CONSTRAINTS OF AI-ASSISTED COMPUTER VISION IN MEDICAL PERSPECTIVES

AI-enabled CV has tremendous potential in transforming healthcare systems. However, this technology also presents important data privacy, accuracy, and regulatory compliance challenges. This section presents the challenges associated with AI-enabled computer vision in healthcare.

2.5.1 Data Bias

The potential perils of prejudice and inequality are inherent in AI-powered CV in healthcare due to its reliance on the data it learns from, which can inadvertently perpetuate biases and discriminatory practices. For instance, the findings from a study by Seyyed-Kalantari et al. (2021) revealed that AI models' ability to diagnose chest X-rays accurately varied significantly across different demographics, including race, despite solely relying on the image. It is worth noting that implementing these models could result in a higher number of misdiagnoses for Black and female patients compared to their White and male counterparts. Despite the underrepresentation of these groups in the training data, it would be oversimplifying the issue to attribute it solely to this factor.

Furthermore, no clear correlation exists between group membership and the prevalence of racial disparities (Gichoya et al., 2022). Moreover, research has revealed that surgical AI systems may mistakenly lower or elevate surgical proficiency by incorporating either an inadequate or excessive skill bias (Kiyasseh et al., 2023). Such biases can potentially affect model accuracy and, consequently, the overall applicability of CV tools in surgery.

2.5.2 Availability and Quality of Data

The success and potency of AI-based CV models are intrinsically linked to the caliber of data used for their training. Nowhere is this more critical than in medical imaging, where cutting-edge imaging apparatus is indispensable for capturing high-quality images, and the judicious expertise of specialists is pivotal in selecting, annotating, and labeling the data (Elyan et al., 2022). Medical image annotation remains one of the most arduous undertakings, necessitating medical professionals' substantial investment of time.

Even with CV advancements, manual annotation remains the predominant method for annotating images in medical and other domains (Castiglioni et al., 2021). This often involves outlining the region of interest with bounding boxes or manually constructing masks using specialized labeling software to facilitate the use of this data in training.

Gathering and labeling data, especially vast collections of videos, is even more formidable and laborious in a multifaceted and ever-changing setting. This task typically requires a significant investment of resources and can often prove to be quite costly (Gumbs et al., 2022). Hence, the dependability of the outcomes of any processing algorithm hinges upon the quality of the image pool furnished as input during the training phase.

2.5.3 Explainability of AI-powered CV Algorithms in Healthcare

The explainability of AI is critical, particularly in healthcare, as patients and healthcare professionals need to understand how the algorithm arrived at its diagnosis or recommendation. Unlike traditional rule-based systems, where the decision-making process is transparent, AI-powered systems are more like black boxes, making it difficult for clinicians to understand decisions (Chaddad et al., 2022). This lack of transparency and explainability can lead to mistrust and, ultimately, hinder the usage of AI-powered systems in healthcare. In addition to the potential mistrust, explainability is also essential for the safety of patients (Angelov et al., 2021).

In healthcare, it is critical to understand why a particular treatment was recommended or why a diagnosis was made. If an algorithm is making recommendations based on data that is not transparent or explainable, there is a risk that the algorithm may make an incorrect recommendation, putting the patient at risk. Therefore, if a clinician is unfamiliar with the intricate workings of the model, they may struggle to convey the intricacies of the treatment process to their patients.

2.5.4 Security and Privacy Concerns

The use of AI-powered CV technology in healthcare raises concerns about patient confidentiality due to its ability to capture images and videos of patients, which can contain sensitive information (Khang et al., 2022a). Therefore, safeguarding healthcare data, which represents an individual's most sensitive information, is paramount, and healthcare providers must take all necessary steps, including the use of various healthcare tools, to ensure patient privacy and information security are upheld at all times (Alli et al., 2021; Kalinaki et al., 2023; Reddy et al., 2020).

In order to avoid causing patients any psychological or reputational damage, it is imperative to safeguard AI-powered systems from privacy breaches. Patients' explicit consent must also be obtained for any particular use of their data (Gutierrez, 2020). This is because training AI-powered models requires a large volume of data about patients for high-quality performance results. For instance, AI devices intended to aid seniors in their homes might silently gather and dispatch information without their awareness. Meanwhile, healthcare providers could furnish patient data to AI creators sans the patients' informed permission (Reddy et al., 2020).

2.5.5 Regulatory Concerns

The cutting-edge technology of AI software and AI-enhanced devices possess an extraordinary capability to self-learn through real-world interactions, constantly improving performance (Ali et al., 2023). This unique feature sets AI-powered techniques apart from other healthcare software, posing unprecedented regulatory hurdles.

In the pursuit of delivering safe and high-quality healthcare to patients, regulatory bodies, healthcare providers, and medical practitioners face the challenge of developing policies and guidelines to govern algorithms that operate in an opaque manner, evolve dynamically with us, and receive automatic updates that may exceed the bounds of their initial approved clinical trials (Čartolovni et al., 2022). As countries grapple with defining regulatory standards for AI algorithmic safety and impact, the absence of clear guidelines poses a double-edged sword for the healthcare industry. While it can hinder the entry of AI into healthcare, it also creates an environment where the application of AI in healthcare can be unsafe (Ruschemeier, 2023; Siala & Wang, 2022).

2.5.6 The Effect on the Relationship between Patients and Physicians

AI is transforming patient and physician relationships by improving patient outcomes and making healthcare more efficient. With AI, physicians can analyze large amounts of patient data, identify patterns, and make more informed diagnoses. This allows physicians to provide personalized treatment plans and better manage chronic