Chapter 10
Future of Medical Decision Support Systems

After having an introduction to the essential topics, the previous chapters have all provided effective use of deep learning for diagnosis of important diseases, as they are base for the medical decision support systems. There are of course many more research aspects to be discussed but if is also a good approach to focus on some insights regarding future of medical decision support systems.

Currently, there are many alternative technologies and innovative developments as bringing revolutionary changes for the humankind. As still the top place is kept by the field of artificial intelligence and its current sub-areas i.e. deep learning, future ideas can be better derived by thinking about possible topics that will greatly affect the future in terms of technological changes—developments, and making the modern life more practical and understandable. A very wide scope can be got if all factors shaping the future are thought but Fig. 10.1 represents a scheme of some of the foremost technologies as well as topics that can be considered as the components for the future scenarios of medical decision support systems.

As we should still think about the artificial intelligence, and deep learning, it is still unclear that the future may have new concepts. However, the role of intelligent systems will be still alive as they will be appearing common components in the context of different technologies and tools—devices. Based on the scope of the medical and relations to medical decision support systems, this chapter provides a final discussion for future developments in the following paragraphs.

10.1 Internet of Health Things and Wearable Technologies

Inter of Things (IoT) is known as a recent technology including intelligent communications of daily-life devices in the context of a network where data share, analyze and acting in a collaboration are all occurred accordingly [1–4]. Because of intense use of the digital world, it has been started to be influencing every task we do during

Fig. 10.1 Some of the
foremost technologies as
well as topics that can be
considered as the
components for the future
scenarios
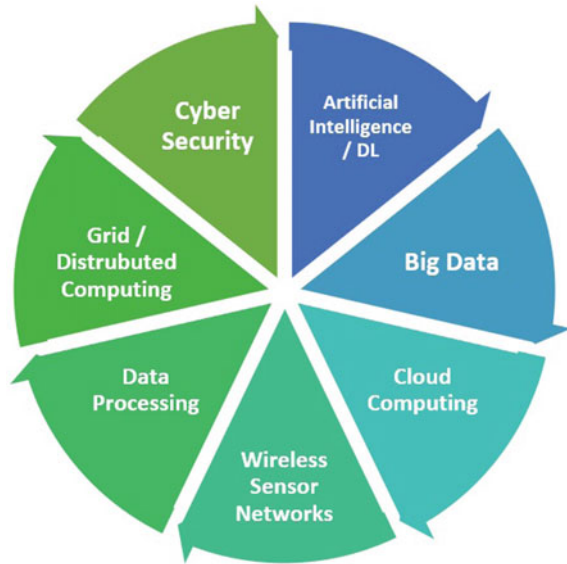
day. As computer as well as communication technologies such as Internet, wireless
communication ensure critical roles in storing the information in the context of a
digital world, the technological developments caused the IoT to rise as a great solu-
tion for an autonomous future with smart devices surrounding us to make everything
easier and more practical (Of course there are many issues appearing within use of
every technology, but that discussion regarding the IoT is another point of interest,
as out of scope of this chapter/book). Briefly, IoT allows communicating among all
devices that can take part in a network so data regarding people, environment, the
other devices can be used accordingly for getting decision makings and performing
some actions such as solving a tasks, adjusting the environmental factors, analyzing
something or at least ensuring interaction with the people in order to inform them
about the world around them. Here, advantages of IoT systems are indicated in
Fig. 10.2.

All the mentioned advantages and the communication-oriented mechanisms of
IoT are all because of innovative developments in artificial intelligence and the
communication solutions such as wireless sensors, wireless communication stan-
dards, and also mobile technologies and communication approaches [5–8]. Nowa-
days, it is remarkable that IoT have already been widely used in different areas [9–13].
As that technology is more employed within a specific field, it is also re-called with
new names, which are appropriate to the scope of the related field. Internet of Health
Things (IoHT) is among them.

IoHT is briefly a type of IoT that is applied for medical applications [14, 15].
Because the future will be probably with full of autonomous devices, use of IoT as
well as IoHT will be probably a common thing because the field of medical will be
always at the first places to benefit from innovative technologies. In accordance to

Fig. 10.2 Advantages of
Internet of Things systems
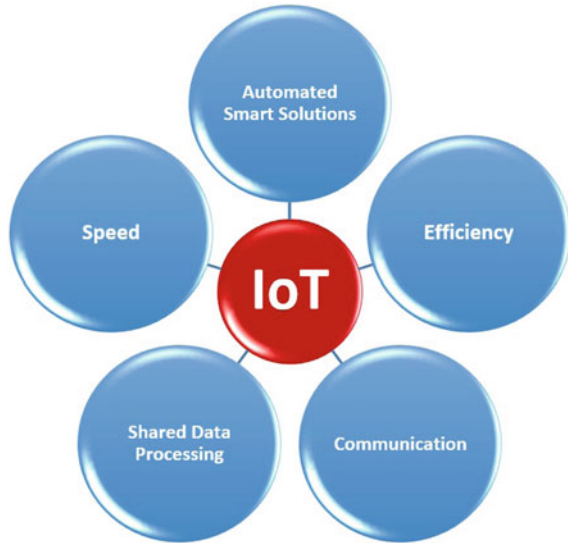
that, the future of medical decision support systems will include intense use of IoHT systems. In detail, possible scenarios will be like as follows:

- After getting up in the morning smart mirrors and cameras in our houses will support us to be ready to the day and they will also track for any mood changes or possible illness.
- Toilets will be devices analyzing urine and stool to make diagnosis of diseases and/or early diagnosis of experiencing bad-way life standards.
- All our medical data will be kept in secure over blockchain running encrypted cloud so that all smart devices will be decision making about our health state.
- Our cars will be tracking our health state and possible tiredness symptoms.
- While working at office environment, smart devices will be tracking our performance as well as mental and health state against any disease or lowering in our well-being.
- Surgeries will be made by decision-making smart robotic systems accurately and in a faster manner.
- All treatments will be tracked by smart devices around us so that we will be faster recovering.
- Thanks to early actions by smart devices, people will not easily be infected or at least be preventing themselves from possible diseases.
- Smart devices will support us to have healthy food and track our medical data for a healthy aging in time.

Since it is still possible to imagine more and more about the possible future scenarios, IoHT here ensure a critical role for supporting us for having good health and well-being generally. As IoHT systems of the future will be associated with deep learning (any maybe more advanced forms with new names), the analyzing,

Fig. 10.3 Essential benefits
to be provided by the future
IoHT systems
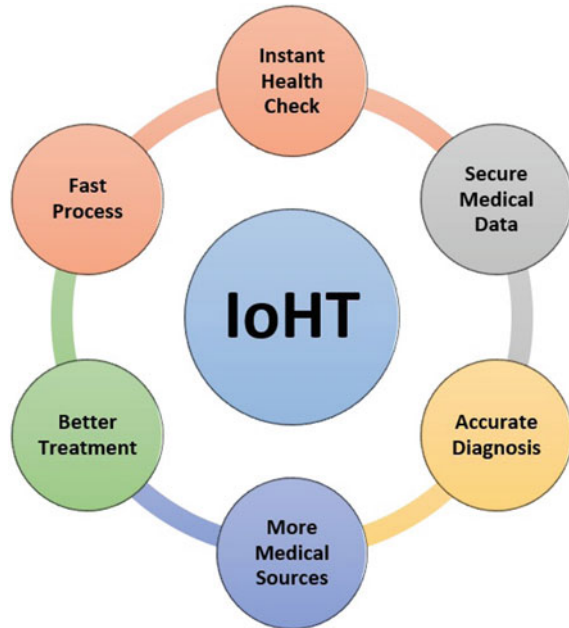
diagnosing, and treatment processes will be even faster and more effective according
to today. Covering all the explanations so far, Fig. 10.3 provides essential benefits to
be provided by the future IoHT systems.

As associated with the IoHT perspective, the future of medical decision support
systems will be also with wearable technologies. Currently, there are many different
types of wearable technologies ready to be used (Fig. 10.4 [14]). Wearable technolo-
gies can effectively track our data and ensure smart features to support us for an
easier life and even decision making generally. Considering the medical, wearable
technologies will be probably common components of IoHT upper-systems and will
be essential tools for understanding more about us and people for ensuring general
well-being.

10.2   Robotics

When a discussion on artificial intelligence and the future is made, the robotics
technologies are certain topic that is widely explained. As appropriate to that, the
future of the medical decision support systems will be intensively associated with
more use of robotics. Even nowadays, there are many examples of robotics usage in
different fields and it is already a constant component of the future [16–18]. In the
context of medical problems and decision support tasks, the following scenarios can
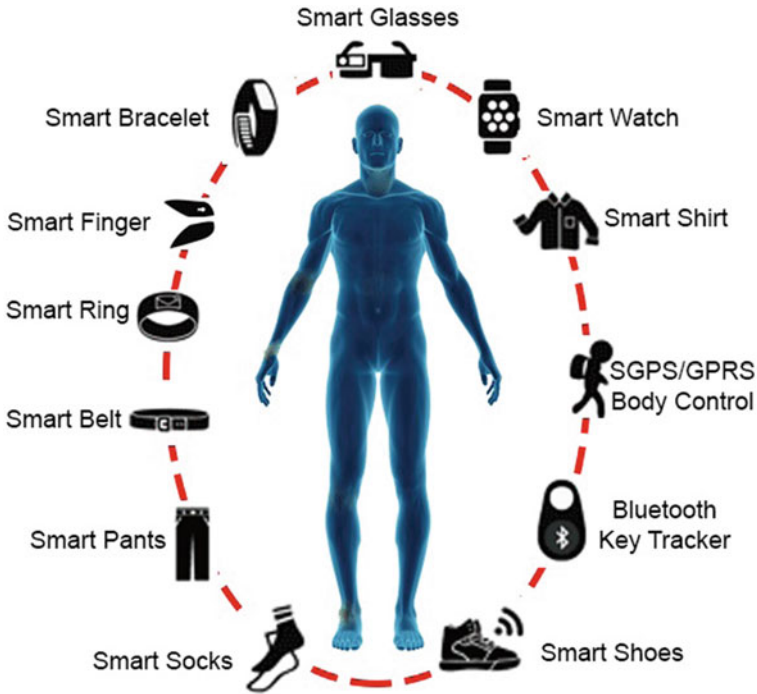be thought accordingly:

Fig. 10.4 Wearable technologies today [14]

- In the future, there will be kiosk-like robotic systems serving public spaces for helping people for simple medical diagnosis and treatments.
- As surgeries are already supported by hard and soft robotics [19, 20], the future will be including wider use of robotics during surgery. Such robotic systems will not only be performing—supporting the surgery but will also help doctors in decision making processes.
- Artificial intelligence is already used in physical rehabilitation applications [21–23]. In the future, there will be more rehabilitation robots and at homes, people (especially older people) will be supported by personal assistant robots with medical knowledge.
- Many of simple medical tests (i.e. taking blood sample) at hospitals will be made by service robotics.
- There will be advanced diagnosis robotics-based rooms for performing general check-up processes.
- Medical tasks that are generally dangerous to be done by humans will be done by robots.
- There will be more use of soft robotics because of their advantages according to hard robotics.

- There will be more robotic expert systems performing answer-question related interactions with people, in order to get ideas about health state, possible disorders/diseases, and collection pre-information for supporting doctors in decision making.
- Robotic systems will be probably even in smaller and as integrated to wearable technologies for better tracking purposes.

10.3   Information and Drug Discovery

As it was mentioned and emphasized in the previous chapters, information discovery is among critical solution ways of the artificial intelligence. Thanks to deep learning and big data use, information discovery has gained more momentum in time. Information discovery can be used to derive new combination of information, wider knowledge and new patterns resulting to the exact mechanism-role of the discovery [24, 25].

Diseases has always been problem for the humankind. Currently, the humankind is even experiencing a pandemic caused by the coronavirus COVID-19 and because of that almost all research works of medical has directed to finding effective treatment of COVID-19. That situation and past experiences with different diseases, which were strong then and weak (or eliminated) nowadays indicate the importance of using information discovery for the drug discovery done with the employment of artificial intelligence in the field of medical. Moving from that, the future will intensively include running drug discovery (discovering medicine—vaccine as well as treatment strategies) by employing effective algorithms—techniques and running them in the context of advanced decision support systems. For even nowadays, there are many examples of drug discovery studies done with deep learning [26–31] so that future diseases, viral infections, disorders and new type of micro-organisms will be often subject to drug discovery studies. Here drug discovery can be an effective step of a whole medical health management system, including use of intelligent systems for analyzes, diagnosis, drug discovery and then treatment processes in the context of a decision support flow, as illustrated in Fig. 10.5.

10.4   Rare Disease and Cancer Diagnosis

Use of automated medical diagnosis as the component of medical decision support systems has already been a good weapon of the humankind for all kinds of diseases. As indicated under the previous paragraph, the future of medical will be still including dealing with infections, micro-organisms and maybe today's vital disease: cancer will be still analyzed, diagnosed and then treated with the use of intelligent systems running medical support systems. Currently, there are already research works done
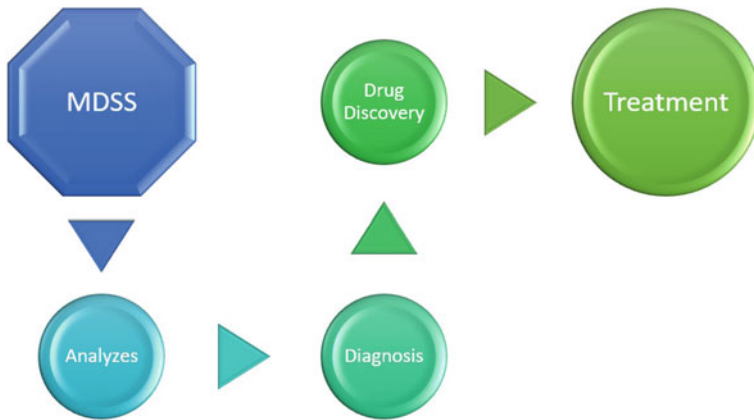
Fig. 10.5 Decision support flow with different steps to be done by intelligent systems

for effective diagnosis of different cancer types [32–42]. With especially good collaboration with image processing, deep learning architectures have been effectively using against cancer diagnosis (Fig. 10.6). On the other hand, there is also rare diseases including i.e. viral, bacterial infections (when they are not pandemic yet), specific allergies, and genetical disorders [43–45]. As some of technological tools and changes in life standards are also affecting directly or indirectly human metabolism and causing rare diseases, there will be still need for medical decision support systems to deal with rare diseases, too. Since it is also possible to ensure a balanced, healthy life thanks to i.e. IoHT systems as explained before, there is still possibility of rare diseases or cancers as there is the chaos in the universe and the nature. However, future intelligent systems will be key factor to deal with such issues, as a remarkable insight for the future.
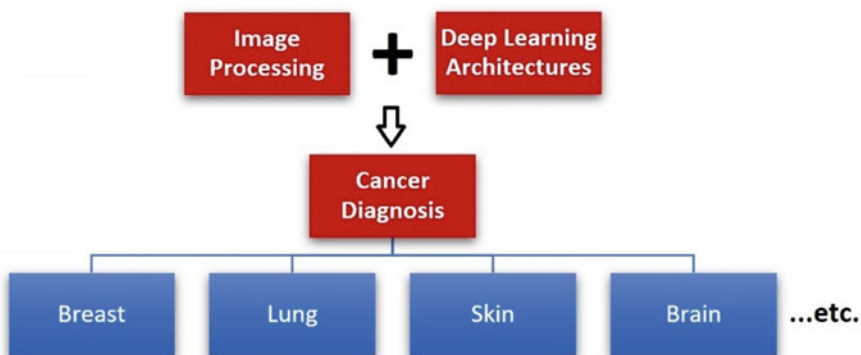

Fig. 10.6 Image processing and deep learning use against cancer diagnosis

10.5   COVID-19 and Pandemics Control

As indicated before, the humankind is currently (at the time of writing that section of this chapter; March 2020) dealing with the coronavirus type: COVID-19 and it became a pandemic in a short time. Because of the COVID-19, governments around the world has applied remarkable policies including breaks at works, schools, universities with remote—online working conditions at homes, quarantines for preventing people from getting COVID-19, which causes deaths in remarkably short times. As general, there is a great emergency state, which is something like the life around the world stopped. That situation has shown researchers to effective use of technology for early diagnosis of such viral infections before they become pandemics or at least running effective treatments and discoveries (i.e. vaccine) rapidly for eliminating that devastating disease. Nowadays, there are already research works focusing on use of artificial intelligence/deep learning for diagnosis of COVID-19 and deriving alternative treatments for it [46–56]. Since that problem has taught many things to the humankind, it can be clearly expressed that the future of medical decision support systems will include pandemics control approaches with deeper analyze and tracking of the data around the world. At this point, a possible system scenario can be expressed briefly as follows (Fig. 10.7):

- The key point in the system is using as much as remote communication possibilities in order to keep near contact of humans against any viral infection appearance. In order to ensure that the IoHT system will be common components of the COVID-19 and pandemic control system.
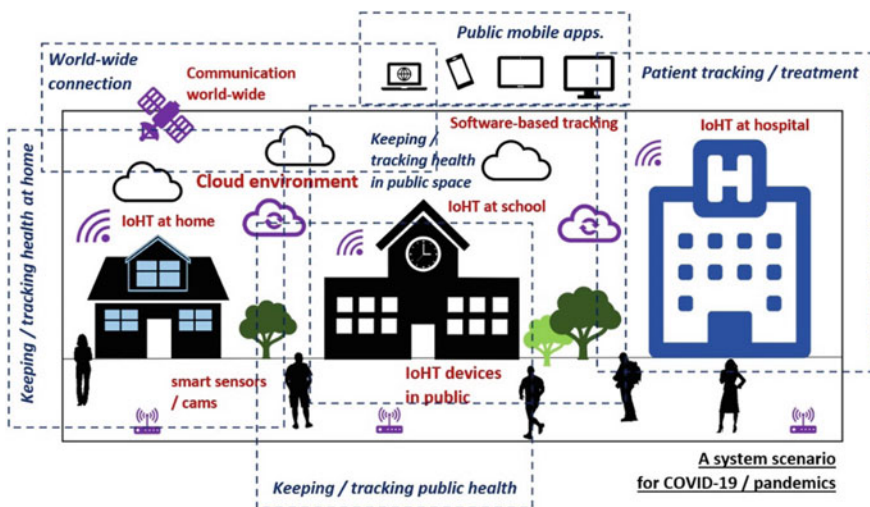

Fig. 10.7   A possible system scenario for COVID-19 and pandemics control

- IoHT based devices will be connected world-wide over cloud systems and the data security will be ensured with effective technologies such as blockchain [57, 58] or tangle [59, 60]. World-wide communication of IoHT based devices will be organized with efficient, optimized approaches and models based on globally accepted standards.
- IoHT devices will include especially following groups of devices: (1) patient tracking and treatment devices at hospitals, (2) public health support devices spread around cities, roads, restaurants, schools, and similar public places, (3) personal health tracking devices at homes (these may be revised according to needs). Roles of these devices will include especially followings:

  - (1) Patient tracking and treatment devices will be used at hospitals for as far as possible interaction with the patients and tracking states of the patients with viral—bacterial diseases remotely. That will also allow doctors, medical staff to track everything in even remote mode and using i.e. e-signatures to give orders or perform any tasks that can be done remotely. Eventually, near interactions of people will be as low as possible except from cases such as surgeries, emergency actions—diagnosis.
  - (2) Public health support devices will support people to keep themselves clean and in safe against diseases. Also, these devices will give people advices, announce emergency states, and ensuring trainings for keeping awareness at a desired level. These devices will also in contact with cleaning services and any other sustainability—green environment technologies in the context of IoT/IoHT.
  - (3) Personal health tracking devices will be responsible to check all people's health state in the same home environment and direct them or ensure communication with hospitals/doctors remotely in case of any suggestions, regular checks, or emergency state predictions.

- As the whole three groups of devices will be in connect with each other, it will be possible to control a virus infection case, by i.e. keeping infected people at home and acting to treat them in accordance to the quarantine rules, perform remote checks—controls at hospitals, improving level of tasks to be done by IoHT devices in public spaces, and many more tasks to do collaboratively by IoHT devices running over artificial intelligence, sensor technologies, mobile communication channels, secure algorithms, and additional technologies to achieve a global, accurate smart system.
- Public spaces will be supported with intense use of sensors, cameras, and drones for achieving better IoT-oriented communication as well as tracking actions for people—public health.
- There will be world-wide software environment allowing public tracking of world-wide viral infections, and also detailed tracking for authorized users such as doctors, policy makers, governments, as having changing authorization levels.
- There will be world-wide up-to-date agreements such as medical data regarding viral—bacterial diseases/infections will be shared instantly around the globe, by securing patient personal data, and the countries will be responsible to share their

data of such diseases/infections with an upper-commission or i.e. World Health Organization.

- There will be of course specially designed diagnosis, treatment technologies and separate smart hospitals, quarantine houses—hotels in case of any pandemic.
- There will be artificial intelligence/deep learning based accurate—fast diagnosis systems, intelligent vaccine development kits, and may be robotics-based services for remote treatment of patients with virus. Analyzes, predictions, control of smart—intelligent systems will be all supported with Data Science and artificial intelligence solutions.
- Thanks to the synergy ensured among IoHT devices world-wide, it will be possible for every people to track spreading of any pandemic instantly, like it is an online streaming video or instantly changing data such as economic time series. As that can be done with mobile applications, such applications will also ensure effective communications, announcements world-wide and country-specific.
- *All the explained working mechanism of the scenario may be revised—updated with addition of alternative technologies, and more use of detailed tasks in control of pandemics such as COVID-19.*

As it can be understood, use of intelligent systems as well as data control—tracking solutions (use of Data Science generally) will give important advantages to the humankind for fighting against pandemics like COVID-19. It is clear that the more a medical decision support system is structured over combinations of solution techniques, the more it could be robust and sustainable for vital medical tasks like predicting, tracking, controlling, treating pandemics.

10.6   Summary

The future of medical decision support systems is all wide open for further research and innovative developments. As a result of improvements and rapid developments in different technologies, the outcomes have always been effective on practical technological solutions for daily-life. After the twenty-first century, that state has been experiencing widely in all different fields. As a critical field, medical will always keep its top place for the newest solutions. Here, solutions by intelligent systems will be key triggering factor for both solving medical problems as well as taking it steps away for better well-being of the humankind.

As also a final touch to this book, this chapter discussed some specific subjects, which the authors think will be important for the future of medical decision support systems. The explanations including IoT, IoHT, wearable technologies, robotics, drug discovery, diagnosis of cancers as well as rare diseases are important topics for further research. Of course, as the current threat for the existence of the humankind, COVID-19 and pandemics have been also discussed in the sense of their control and treatment, as the final, vital topic.

As concluding comments for the book, the authors have provided a current view on use of deep learning for rising medical decision support systems. Employment of different deep learning architectures, using them for especially diagnosis solutions so forming essentials of medical decision support systems are rapidly improving research topics so that there will be always need for such reference book for better understanding the latest research and having future ideas. The authors would like to thank all readers for reading that book and desire to see same interests for the future works by them.

10.7 Further Learning

In order to have some more future insights from very recent works regarding future of artificial intelligence as well as its role in medical, readers can read [61–76].

For learning more about smart medical applications (with especially support by IoT, mobile communication, and some other technologies) as well as some future perspectives, the readers are referred to [77–81].

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