Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Chapter 9

Rapid medical guideline systems for COVID-19 using database-centric modeling and validation of cyber-physical systems

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9.1 Introduction

The massive damage on humanity has recorded in the history of a global pandemic; Spanish flu Ebola, Asian flu, severe acute respiratory syndrome (SARS) are different pandemics in the past decade, but COVID-19 has rolled out the entire world as of August, 2020 with 20,730,456 people infected, and 75,1154 losing their lives. This number creates mental health problems for normal human beings with stress, worry, lack of sleep, and emotional issues. As of August, 2020, there has been no proper vaccination found for this virus. More investigation are seriously working to find the vaccination but virus spread as fast among people currently the challenges amplified in rural areas. Due to the unavailability of COVID-19 medical experts, a huge spread in rural places (Hadi, Kadhom, Hairunisa, Yousif, & Mohammed, 2020). To overcome this problem, database-centric medical guideline systems are mandatory to avoid mental stress in an average person.

A database-centric approach in the medical guideline system was already implemented in 2008 (Islam, Hasan, Wang, Germack, & Noor-E-Alam, 2018). The analysis of European research projects in the current year shows most of the artificial intelligence-based medical guidelines systems are involved in the medical sector. Rapid medical guidelines systems based on cyber-physical systems with proper modeling, simulation, and validation are necessary during the COVID-19 pandemic.

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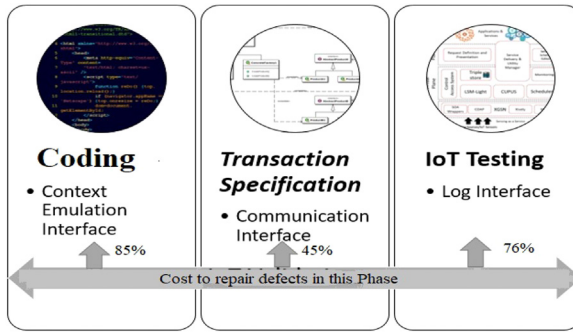

FIGURE 9.1 Cost expenditure percentage during re-engineering.

Rapid medical guidelines system based on cyber-physical systems can be more eye-catching among software developers (Guo, Fu, Zhang, Ren, & Sha, 2019). The cyber-physical courses, such as the human − machine interaction process during a global pandemic, are challenging to identify the preconditions during the development (Fox, Johns, & Rahmanzadeh, 1998).

Re-engineering is essential for the rapid medical guidelines system. Validation has assured the quality of products during the fast medical guidelines system (Guo, Fu, Zhang, Ren, & Sha, 2020; Shah, D. et al., 2019). The modeling and validation techniques are controlled by a simulation invocation relationship. Fig. 9.1 describes the percentage of cost spent on the dedication of defects in the different phases of rapid medical system development. The proposed simulation invocation algorithm identified the simulations to be affected during the human − machine interaction process. A medical professional-based methodology aims to improve the effectiveness of the product and reduce the development cost. To solve this problem, a stack allocation-based framework was proposed that utilizes two sources of information, which are code coverage and test execution time.

This rapid medical system helps rural medical officers and normal human beings to avoid unnecessary mental stress. The following sections describe the global pandemic COVID-19, framework for database-centric cyber-physical design, modeling, and validation techniques for rapid medical systems in detail.

9.2 Global pandemic of COVID-19

In late 2019 a novel type of coronavirus was identified as 2019-NCOV. COVID-19 arised in Wuhan, China. During March, 2020, the COVID-19 was declared as a global pandemic. In the past two decades, after SARS, yellow fever, cholera, and Ebola virus disease, respiratory coronavirus was detected in humans called COVID-19. It belongs to the family of coronaviruses, roniviridae, arteriviridae. The family is divided into alpha, beta, and gamma (Hadi et al., 2020). The pandemic in December 2019 was introduced

with new cases in China. According to the laboratory investigation and earnest of the report finally recognized the virus were classified as COVID-19. On February 11, 2020, the World Health Organization stated the most famous name of the viruses as COVID-19.

The origin of COVID-19 in Wuhan, few adults went to local hospitals with severe respiratory symptoms for an unknown reason in November 2019. After SARS diseases spreading the control system and patient respiratory samples were sent to the references lab to discover the cases. The virus was recognized about 78% of similarity to SARS samples that were taken from the connectivity to human-related to the seafood markets were also positive, indicating that this virus was generated from seafood. The population of Wuhan around 11 million they were restricted with the public transaction with even though on January 2020 other cases appeared in Japan, South Korea, and Thailand on February 26, 2020, the confirmed cases according to the World Health Organization coronavirus database 56,650. In the first week of August 2020, around confirmed death is 731,641 were 19,905,163 cases worldwide Fig. 9.2.

The COVID-19 is confirmed in the 215 global countries as per the source from World Health Organization on August 15, 2020. COVID-19 pandemic is having a disproportionate impact on their livelihoods around all the sectors (Guo et al., 2016). Tourism revenue loss between January and May is "more than three times the loss during the Global Financial Crisis of 2009" reported by the World Tourism Organization. Millions of smallholder family farmers in Asia-Pacific produce a majority of the world's food. In Asia-Pacific, smallholder farmers own and operate the majority of farmland. The production of 75% has sold on to markets. The lockdown during this global pandemic restrictions in markets to curb the spread of COVID-19 the smallholder farmers have shattered the revenue.

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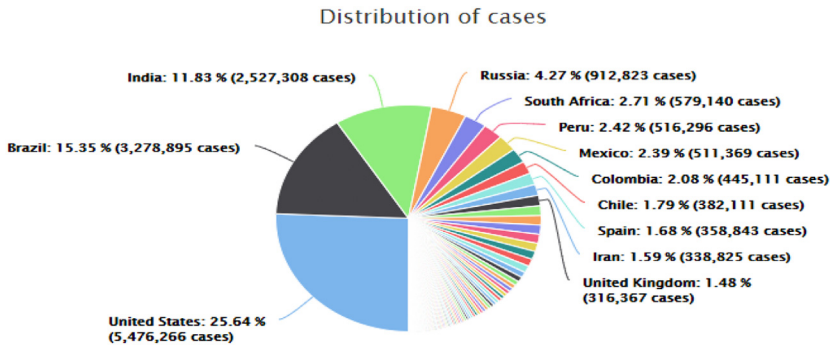

FIGURE 9.2 Globally first 100 days confirmed cases of COVID-19 reported to WHO.

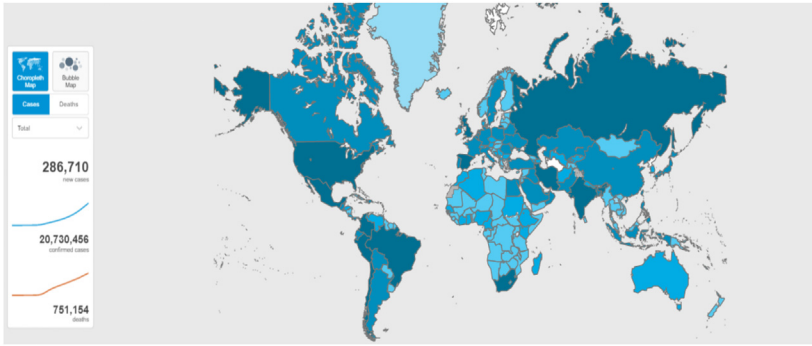

FIGURE 9.3 Global pandemic of COVID-19. *World Health Organization as on August 15, 2020.*

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The survey had 1556 respondents working professionals in the 22−45 age bracket, from five major world cities as layoffs and pay cuts in the wake of the pandemic have impacted people's cash flows. The production company's history had never shown zero production and zero sales, but due to the global pandemic of COVID-19, it was an unprecedented quarter result in a lockdown. To avoid the economic slowdown, rapid medical guideline systems for COVID-19 using database-centric cyber-physical systems are necessary for hospitals. The rapid system needs to be developed with less time and error-free during the COVID-19 pandemic. Effective modeling and validation will produce the errorless system in the medical sector for human interaction.

9.3 Database-centric cyber-physical systems for COVID-19

9.3.1 Cyber-physical systems

The availability of health facilities for humans is the fundamental human right in the world (Kim et al., 2010). As reported in the last section, the global pandemic of COVID-19 has challenged the health facilities such as medical specialists, healthcare components, and druggists to provide health services to humans. The huge demand for professionals in the medical field. Over the past several years, many healthcare applications have been developed to

enhance the healthcare industry (McKinley et al., 2011). Recent improvements in information technology have revolutionized electronic healthcare research and industry (Rahmaniheris, Wu, Sha, & Berlin, 2016). Database-centric and artificial intelligence are currently two of the most important and trending pieces for innovation and predictive analytics in healthcare, leading the digital healthcare transformation (Shah, AD et al., 2019). The benefits of using this new data platform for community and population health include better healthcare outcomes, improvement of clinical operations, reducing costs of care, and generation of accurate medical information.

The benefits of using this database-centric cyber-physical system for public community provides the better healthcare outcomes during the global pandemic, improvement of clinical operations, reducing costs of care, and generation of accurate medical information are the huge demand in rural places of the world. "Every village in the country would be connected with the optical network within 1000 days or less than three years," Prime Minister Narendra Modi said at the ramparts of Red Fort on India's 74th Independence Day. The demand in the rural places for COVID-19 medical professionals is reduced if database-centric cyber-physical systems are implemented in the rural places worldwide.

9.3.2 Flow of rapid database-centric cyber-physical system

Different wearable sensors are connected between database-centric cyber-physical systems and target humans (Xiao, Wang, lin, & Yu, 2008). Database from humans through an extensive-scale network worldwide provides an efficient and effective way of data collection, processing with medical professionals, and generating the solution during the global pandemic of COVID-19. The COVID-19 healthcare system needs the cyber-physical system-based decision-marking applications, clinical algorithms, databased centric of patient's information, and digital pharmaceuticals applications. Data-centric standardization and communication protocols can enable the medical system to deliver efficient healthcare services. Several stakeholders, such as patients, hospitals, and pharmacies, have accessed and securely maintained health records with less energy. Fig. 9.4 shows the flow of rapid database-centric cyber-physical systems for COVID-19. The rapid medical system for COVID-19 is inbuilt in professionals for monitoring the applications and patient information. The server connects the database-centric with smart contracts. The storage collects the data from sensing devices from the healthcare system—the sample interaction between the proposed devices, as described in the following section.

These incidents of system failures in database-centric cyber-physical systems indicate an inarguable fact that unspecified assumptions are dangerous and can lead to catastrophes. However, system developers continuously make assumptions about the interpretation of requirements, design decisions,

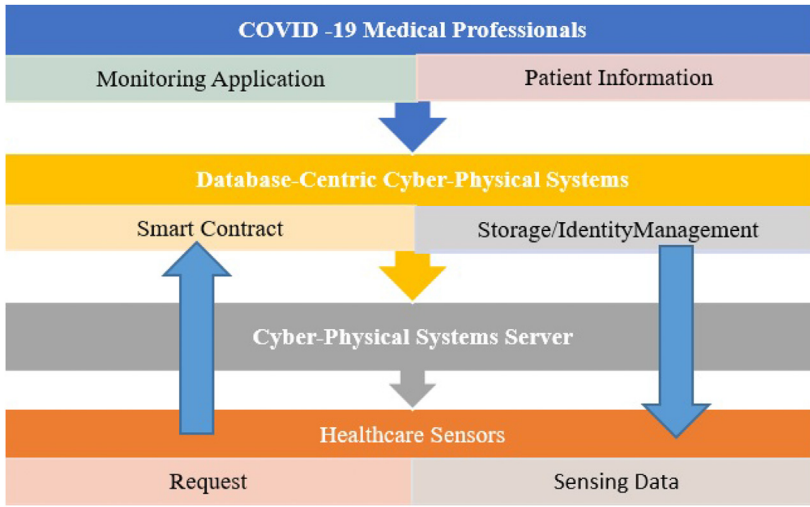

FIGURE 9.4 The flow of rapid database-centric cyber-physical systems for COVID-19.

the operational environment, characteristics of input data, and other factors during system development and deployment phases (Andrade and Machado, 2013). But these assumptions are seldom documented and less frequently validated by the domain experts who know to verify their appropriateness. Once the operating environment of cyber-physical systems violates the unspecified beliefs, failures may occur, and catastrophic accidents may happen, resulting in loss of revenue in the tune of hundreds of millions of dollars and loss of lives. A cyber-physical system for COVID-19, its execution behaviors are often impacted by its operating environment. However, the assumptions about a cyber-physical system's expected environment are often informally documented, or even left unspecified in the system design. Unfortunately, such anonymous system design environment assumptions made in safety-critical cyber-physical systems, such as medical cyber-physical systems performance as the medical professional in the world's rural places during the massive demand in the global pandemic.

9.4 Modeling and validation of rapid medical guideline systems

Software modeling and validation is significant for all the software development processes (Padmanabhan and Prasanna, 2017b). Rapid medical guideline systems are essential during COVID-19 for perfect testing because failures of software can cause serious damage. An unified modeling language

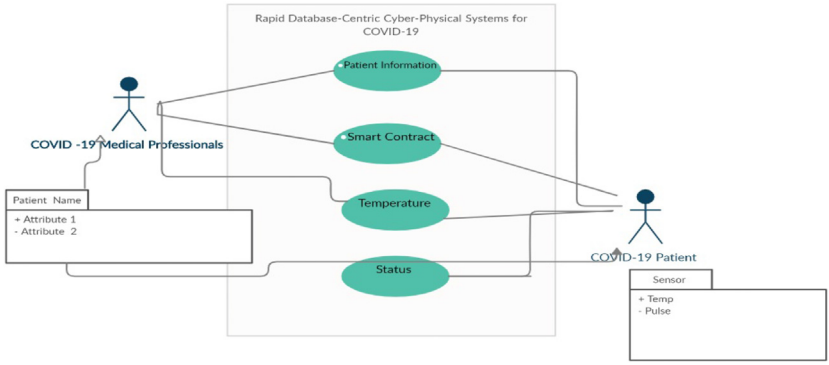

FIGURE 9.5 Modeling and validation of rapid database-centric cyber-physical systems.

sequence diagram has been recycled. Fig. 9.5 shows the process diagram with the binary value for the interaction between the human and cyber-physical systems.

The approach determines the goal of the patient interaction with medical professionals to find more important and effective potential data to find faults with less execution time with more code coverage. To support this goal, the proposed algorithm should find a stack simulation with a higher gain value and visit the stack at least once during the allocation (Padmanabhan and Prasanna, 2016; Padmanabhan and Prasanna, 2017a; Padmanabhan, 2018; Padmanabhan, 2019; Padmanabhan, 2020; Wang et al., 2018).

The Jaccard similarity methodology are well suitable for finding textually similar documents (Bingquan et al., 2018). To find the duplicate request in the stack flows, the minhash value to set S and T is |S U T|/|S ∩ T |, that is the ratio of the size of S and T's intersection the size of their union. The Jaccard similarity of S and T is to be represented by sim(S, T) (Wang et al., 2018). Textual similarity has importance during the huge demand worldwide for medical professionals. The Jaccard similarity addresses well about finding textually similar documents in an extensive system interaction in web or social media (Bhatnagar et al., 2020). The textual similarity has importance during the validation. This proposed technique reduced the cost and time during the chatbot testing.

Table 9.1 shows the list of sample interaction in the process rapid database-centric cyber-physical systems for COVID-19. The condition checking if the data are unavailable then produces the fallback message to the user. During the human discussion, the duplicate dialog flows have been counted to reduce the time during medical professional's interaction.

The proposed test path similarity identification methodology based on the minhashing matrix representation of collaborative modeling has yielded significant results in the rapid medical systems for COVID-19 interaction.

TABLE 9.1 List of sample requests to rapid medical systems for COVID-19.

Request ID	Sample source (sets S and T)	Jaccard similarity ID [sim(S, T)]	minhash value | S U T|/|S ∩ T|
R1	I am fine	J1	1
R2	I am well or not?	J1	0
R3	When will you discharge me?	J3	1
R4	I am in critical?	J1	0
R5	Tell my body temperature?	J4	0
R6	My last COVID-19 results shows positive or negative?	J5	1

9.5 Conclusion

The proposed rapid medical systems for COVID-19 allow us to address the health challenges and better understand patients' health during the global demand in medical professionals. It may not always be feasible for domain experts to identify the most safety-critical ones at different system development phases. Validation is mandatory in all the subdivisions of the system. Therefore, the proposed methodology uses the similarity index and database-centric cyber-physical technology. Software development steps with the validation technique of the cyber-physical system for COVID-19 address 99.5% issues in the world's rural places. In particular, the system development process with validation and verification in the design level and the development of rapid medical guideline systems for COVID-19 has a live connection with database-centric modeling and COVID-19 medical professionals. Thus the medical professional's study-based design of the medical guidelines system for COVID-19 has reduced development time, cost of deployment, testing, and maintenance based on the sample verification flow. More future work needs to be done on the platform to continue improving all the benefits for the entire health organization. Tools for performing the knowledge discovery process will be added to the rapid database-centric cyber-physical systems.

References

Andrade, W. L., & Machado, P. D. L. (2013). Generating test cases for real-time systems based on symbolic models. *IEEE Transactions on Software Engineering*, *39*(9), 1216–1229. Available from https://doi.org/10.1109/TSE.2013.13.

Bhatnagar, V., Poonia, R. C., Nagar, P., Kumar, S., Singh, V., Raja, L., & Dass, P. (2020). Descriptive analysis of COVID-19 patients in the context of India. *Journal of Interdisciplinary Mathematics*, 1–16.

Bingquan, L., et al. (2018). Content-oriented user modeling for personalized response ranking in chatbots. *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, *26*(1)).

Fox, J., Johns, N., & Rahmanzadeh, A. (1998). Disseminating medical knowledge: The PROforma approach. *Artificial Intelligence in Medicine*, *14*(1–2), 157–182. Available from https://doi.org/10.1016/S0933-3657(98)00021-9.

Guo C., S. Ren, Y. Jiang, P.-L. Wu, L. Sha, & R.B. Berlin, Transforming medical best practice guidelines to executable and verifiable statechart models, in 2016 ACM/IEEE 7th International Conference on Cyber-physical Systems (ICCPS), Vienna, Austria, April 2016, pp. 1–10, Available from https://doi.org/10.1109/ICCPS.2016.7479121.

Guo, C., Fu, Z., Zhang, Z., Ren, S., & Sha, L. (2020). A framework for supporting the development of verifiably safe medical best practice guideline systems. *Journal of Systems Architecture*, *104*, 101693. Available from https://doi.org/10.1016/j.sysarc.2019.101693, Mar.

Guo, C., Fu, Z., Zhang, Z., Ren, S., & Sha, L. (2019). Design verifiably correct model patterns to facilitate modeling medical best practice guidelines with statecharts. *IEEE Internet of Things Journal*, *6*(4), 6276–6284. Available from https://doi.org/10.1109/JIOT.2018.2879475.

Hadi, A., Kadhom, M., Hairunisa, N., Yousif, E., & Mohammed, S. (2020). A review on COVID-19: Origin, spread, symptoms, treatment, and prevention. *Biointerface Research in Applied Chemistry*. Available from https://doi.org/10.33263/BRIAC106.72347242.

Islam, M., Hasan, M., Wang, X., Germack, H., & Noor-E-Alam, M. (2018). A systematic review on healthcare analytics: Application and theoretical perspective of data mining. *Healthcare*, *6*(2), 54. Available from https://doi.org/10.3390/healthcare6020054.

Kim C., M. Sun, S. Mohan, H. Yun, L. Sha, & T.F. Abdelzaher, A framework for the safe interoperability of medical devices in the presence of network failures, in Proceedings of the 1st ACM/IEEE International Conference on Cyber-Physical Systems—ICCPS '10, Stockholm, Sweden, 2010, p. 149, Available from https://doi.org/10.1145/1795194.1795215.

McKinley, B. A., et al. (2011). Computer protocol facilitates evidence-based care of sepsis in the surgical intensive care unit. *The Journal of Trauma: Injury, Infection, and Critical Care*, *70*(5), 1153–1167. Available from https://doi.org/10.1097/TA.0b013e31821598e9.

Padmanabhan, M., & Prasanna, M. (2017a). Test case generation for embedded system software using UML interaction diagram. *Journal of Engineering Science and Technology*, *12*(4), 860–874.

Padmanabhan, M., & Prasanna, M. (2017b). Validation of automated test cases with specification path. *Journal of Statistics and Management Systems, Issue on Machine Learning and Software Systems*, *20*(4), 535–542.

Padmanabhan M., 2018 A study on transaction specification based software testing for internet of things, in IEEE International Conference on Current Trends towards Converging Technologies (ICCTCT 2018), March1–3, 2018, Coimbatore, India.

Padmanabhan, M. (2019). Sustainable test path generation for chatbots using customized response. *International Journal of Engineering and Advanced Technology*, *8*(6), 149–155. Available from https://doi.org/10.35940/ijeat.D6515.088619.

Padmanabhan, M. (2020). Test path identification for virtual assistants based on a chatbot flow specifications. In K. N. Das, J. C. Bansal, K. Deep, A. K. Nagar, P. Pathipooranam, & R. C. Naidu (Eds.), *Soft Computing for Problem Solving* (Vol. 1057, pp. 913–925). Singapore: Springer Singapore.

Padmanabhan M., Prasanna M., Automatic test case generation for programmable logic controller using function block diagram. IEEE International Conference on Information Communication and Embedded System (ICICES 2016), Chennai, India, ISBN: 978−1−5090−2552-7, 2016.

Rahmaniheris M., P. Wu, L. Sha, and R.R. Berlin, An Organ-centric best practice assist system for acute care, in 2016 IEEE 29th International Symposium on Computer-based Medical Systems (CBMS), Belfast and Dublin, Ireland, June 2016, pp. 100−105, doi: 10.1109/CBMS.2016.12.

Shah, A. D., et al. (2019). Recording problems and diagnoses in clinical care: Developing guidance for healthcare professionals and system designers. *BMJ Health & Care Informatics*, *26* (1), e100106. Available from https://doi.org/10.1136/bmjhci-2019-100106.

Shah, D., et al. (2019). Recording problems and diagnoses in clinical care: Developing guidance for healthcare professionals and system designers. *BMJ Health & Care Informatics*, *26*(1), e100106. Available from https://doi.org/10.1136/bmjhci-2019-100106.

Wang, H., et al. (2018). Social Media-based conversational agents for health management and interventions. *Computers*, *51*, 26−33, August.

Xiao C., W. Wang, X. lin, and J.X. Yu, Efficient similarity joins for near duplicate detection, Proc. WWW Conference (2008), pp.131−140.