A Smart Surgery Guide (SSG): An innovative deep learning-based surgery approach for Healthcare Informatics

Rudresh V. Kurhe[1], Anirban Sur[2]

Symbiosis Institute of Technology, Symbiosis International (deemed) University, India
Symbiosis International University, Pune, India
rudresh.kurhe.btech2019@sitpune.edu.in, anirban.sur@sitpune.edu.in

Abstract:

A smart surgery guide is presented in this study (SSG). The goal is to assist and train the surgeon in stabilizing the patient during surgery and to improve the surgical process by utilizing cutting-edge technology (e.g., IoT, ML). The smart surgery guide is a system that collects, process, and analyses real-time sensor data (e.g., Oximeter, Optical Heart Rate Sensor, Thermometer, Blood Pressure Sensor, etc.) and then apply the deep learning model to build a surgery model using past surgery data to help you learn from previous surgery errors or life-saving methods and provide you with the best surgery solution. SSG will play an important part in training purposes. It aids the aspiring student in comprehending the procedure and scope of surgery. It can help to train for surgery by providing critical situations during practice to help develop decision-making abilities during operations. In this paper working of smart surgery has been discussed in detail.

Keywords.. Smart Surgery, Patient monitoring, Internet of things, Deep learning

1. INTRODUCTION

The purpose of the Smart Surgical Guide is to eliminate human error and improve surgical skills during surgery. According to the report, doctors' errors injure more than 12 million patients each year, according to the World Health Organization. The Smart Surgical Guide is particularly helpful in reducing surgery errors because it suggests the ideal surgery model based on real-time sensor data analysis. That allows doctors to learn from previous mistakes made during these types of surgeries, as well as life-saving techniques that help save the patient's life [1-5].

Apprenticeship and shadowing are the traditional methods of surgical training. Technical competence evaluation is subjective and heavily reliant on mentors, only reflecting the trainee's expertise. Certain characteristics of this system obstruct students' technical training. **SSG** can, on the other hand, assist us in revolutionizing surgical education and training. **SSG** is described as a computer's ability to conduct behaviour that is like those performed by the human brain. It can be used to objectively assess a trainee surgeon's surgical abilities. Machine learning techniques can be used by artificial intelligence to analyze large data sets to analyze operator performance [6, 12].

The SSG plays a critical function in the tenth stage of surgery to train doctors to save the patient's life. It allows doctors to make many complex processes with accuracy, flexibility and control as possible with common techniques. Surgeons that use the SSG claim that it enhances precision, flexibility, and control during surgery while also enabling them to visualise the site better as compared to conventional methods.

Using the SSG system during surgery, surgeons can carry out delicate and complicated therapies that would be challenging or impossible using conventional techniques [13]. Massive amounts of data can now be used for educational purposes thanks to advances in artificial intelligence and machine learning [14, 15]. Artificial intelligence's use in education has come under fire for its algorithms' lack of openness in its decision-making processes..

The purpose of this study is to 1) explain artificial intelligence and 2) validate the framework by creating a platform for automated instructional feedback called the Virtual Operative Assistant. Additionally, robotic surgery and surgery automation both depend on it. The importance of surgical systems is increasing in the field of automatic handling operation theatre as a result of the expansion of the Internet of things (IoT) [16] in the medical industry. For a city to become smart, its healthcare system must be advanced. Every action has a greater benefit when taken in an atomized fashion than when taken traditionally [17].

2. METHODOLOGY

2.1. System Requirements:

Patient monitoring is an important component of surgery, and we need a guide who can tell us what different techniques have been employed by doctors in the past to rescue patients during surgery. The machine learning model used previous cases to assist you in stabilizing the patient's state during operation. We think that SSG enhances the surgeon's control, precision, and flexibility during surgery while also enhancing their ability to visualise the area. Using the SSG system during surgery, surgeons can carry out delicate and complicated therapies that would be challenging or impossible using conventional techniques. [18].

2.2. System working

We used a variety of sensors to keep track of the patient (e.g., Oximeter, Optical Heart Rate Sensor, Thermometer, Blood Pressure Sensor, etc.). The Node MCU is essential to the success of Operation Theatre. Using the integrated Wi-Fi module, it gathers data from all sensors and sends it to the cloud service layer. Using real-time sensor data and the ML model, it will assist us in keeping an eye on the patient. Using real-time sensor data, a trained With the aid of a prior instance, machine learning models on the cloud can forecast the optimal course of action during surgery. Data is obtained from a Google Firebase cloud computing platform and sent to applications by the processing layer. The smart display displays sensor data at various phases of the process along with the best available guidance and solution in the form of animation [19]. Wi-Fi modules support the use of web-based mobile interference to monitor the real-time data (fig1.). the elements listed below make up Fig. ESP8266, 2. An optical heart rate sensor. Oximeter Thermometer 3. 4. A blood pressure monitor

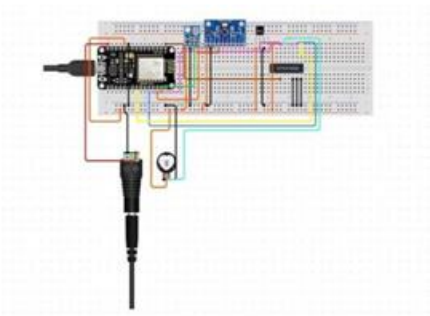

Figure1. Circuit Diagram

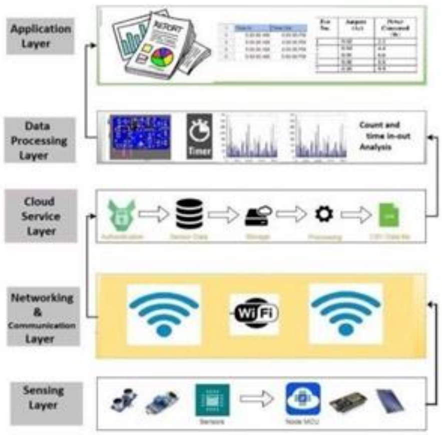

Figure 2: - Layer of working

2.3. Detailed of Layered Design

• Sensor Layer: The detecting layer is composed of several sensing modules, such as an infrared sensor module, an infrared temperature detection sensor, an anode microcontroller, and extra patient monitoring sensors...

• Networking Layer: The Web and mobile interfaces, Google Firebase, the MQTT broker architecture, and the networking and communication layer are all connected to the sensing layer by this layer. • Cloud Layer: Data from sensors are tracked by the cloud layer. assist in using data. A Google Firebase database is an open-source cloud platform used by the system being presented. live information. After processing, the data is transferred to the application layer for additional review.

Processing Layer: This layer regulates how data is received from the Google Firebase cloud computing platform using the MQTT broker architecture.

3. DEEP LEARNING MODEL LAYER DESIGN

CNN, a subclass of feed-forward neural networks, serve as one example. The two main CNN layers—convolutional and pooling—are the focus of this work. Convolutional layers are one type of layer. The foundation of CNN is convolution. The filter can be likened to the layer's neuron because it provides an output value and has a weighted input..

Since filters may only travel along the x- and y-axes to extract features, convolution is effectively a two-dimensional spatial filtering technique. In order to build feature maps, it is necessary to precisely determine the number of filters and their kernel sizes. In swimming Layer the number of parameters in feature maps is still too high after the convolutional layer. As a result, the pooling layer is used for subsampling.

Pooling extracts important characteristics while also decreasing the complexity of feature maps by reducing their size. The main objective of pooling, also known as maximum pooling and average pooling, is to select the maximum or average value to produce a new feature map. In order to build better models, we can utilise CNN to extract traits from input data. Long Short-Term Memory Network (LSTMN)

The LSTM Network, an upgraded RNN (sequential network), enables data retention indefinitely. It can fix the vanishing gradient problem with RNN. For persistent memory, one uses a recurrent neural network, or RNN. The nodes in each layer of a standard neural network model are fully unconnected, while the layers themselves are completely coupled. As a result, it is ineffective at resolving sequence problems. Time sequences for sensor data, as previously mentioned. In order to do this, recurrent neural networks. In contrast to conventional neural networks, RNN's hidden layer nodes are connected. The input of the hidden layer also contains the output of the hidden layer from the time slot prior, in addition to the output of the input layer. Recurrent connections within the network may eventually facilitate feedback and memory.. The gradient of the neural network may become unstable when back-propagation is used in a very deep RNN, leading to the growing gradient problem or even the vanishing gradient problem, which makes the produced model untrustworthy. LSTM,which use long short-term memory, can address these problems. In fact, the LSTM is an RNN variant with many of gates and memory units.

3.1. Convolutional Neural Network -LSTM Method

As noted earlier, we employ a hybrid model that combines CNN and LSTM to forecast values based on sensor data. After entering the sensor data, CNN first extracts the features. The characteristics are then sent into an LSTM for more training. Figure 3 depicts the suggested model's topology.

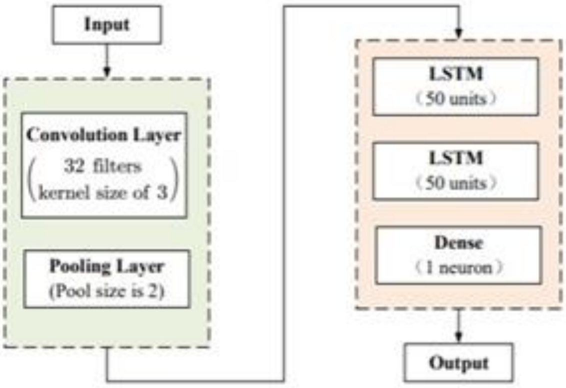

Figure 3. Model Layer

The windows prediction methodology increases forecast accuracy by estimating the values of the forthcoming time slot using sensor data from several recent time slots. We must link the input and output data in order to create a training and validation data set. Next, zero-mean (z-score) normalisation is used to transform the sensor data. Data are represented by $X = \{x^1, x^2, \ldots, x^t \ldots\ldots, x^T\}$, for each entry in the data x^t equation is an example of z-score normalisation showing in equation1..

$$z^t = \frac{x^t - x^t_{mean}}{x^t_{std}}, \qquad \ldots\ldots\ldots\ldots(1)$$

It's worth noting that the model's input contains n_W data, which adds to the model's complexity. In addition, as n_W increases, the input characteristics become scarce and harder to extract. As a result, we employ CNN to extract characteristics from sensor data. For greater subsampling and maximum pooling, a pooling layer with a pool size of 2 is added after inserting a convolutional layer with 32 filters and a kernel size of 3. The input features have now been successfully recovered and are simpler than the initial input data. After that, two 50-unit LSTM hidden layers receive the features for extra training. Because the prediction problem is truly a regression problem, we utilise the dense layer (i.e., fully connected layer with one neuron) to receive the tensor from the LSTM hidden layer and The output has been completed with the desired values. Because of the advantages of LSTM's time sequence advantage and CNN's feature extraction skills, the suggested method predicts outcomes better

4. CONCLUSIONS AND FUTURE ENHANCEMENTS

In urgent situations, this smart display directs medical professionals and aids in patient lifesaving.

The machine learning model helps us to offer the best answer in urgent situations, enabling us to give impeccable advise to prevent making the same mistakes twice. As noted earlier, we employ a hybrid model that combines CNN and LSTM to forecast values based on sensor data..

The major finding from this study:

- Smart Surgical Guide is to eliminate human error and improve surgical skills during surgery.
- SSG can, on the other hand, assist us in revolutionizing surgical education and training. SSG is described as a computer's ability to conduct behaviour that is like those performed by the human brain.
- In the tenth stage of surgery, the SSG plays a crucial role in educating surgeons on how to preserve the patient's life. Surgeons that use the SSG claim that it enhances precision, flexibility, and control during surgery while also enabling them to visualise the site better as compared to conventional methods.

Technologies like artificial intelligence and machine learning have created new ways to use massive amounts of data for educational purposes SSG can be a vital part of any medical organization's training programme for future surgeons and can also aid to increase accuracy. It is used to maintain the stability of patients and with the help of the deep learning model, it helps to make crucial decisions in major operations. It can improve our medical system and guide us with more effective ways to save a life. We used an IoT-based robotic arm to operate on the patient with the help of machine learning guidance. This is completely automated robotic equipment, and its features enable doctors to control the arm during surgery. It operates on humans and will be directed by a doctor, reducing human error and ensuring accurate surgery

References

[1] Nabel, E.G. Cardiovascular disease. N. Engl. J. Med., 349, 60–72, 2003.

[2]. Al-Absi, H.R.H.; Refaee, M.A.; Rehman, A.U.; Islam, M.T.; Belhaouari, S.B.; Alam, T. Risk factors and comorbidities associated to cardiovascular disease in Qatar: A machine learning based case-control study. IEEE Access, 9, PP29929–29941, 2021.

[3]. Mancia, G.; Sega, R.; Milesi, C.; Cessna, G.; Zanchetti, A. Blood-pressure control in the hypertensive population. Lancet, PP349, 454–457. 1997

[4]. SPRINT Research Group. A randomized trial of intensive versus standard blood-pressure control. N. Engl. J. Med., 373, PP2103–2116, 2015

[5]. Mahmood, S.N.; Ercelecbi, E. Development of blood pressure monitor by using capacitive pressure sensor and microcontroller. In Proceedings of the International Conference on Engineering Technology and their Applications (IICETA), Al-Najaf, Iraq, 8–9 May 2018; pp. 96–100. Electronics, PP10- 15, 2021

[6]. Pandya, S. *et al.* . A Novel Multicast Secure MQTT Messaging Protocol Framework for IoT-Related Issues. In: Singh, P.K., Wierzchoń, S.T., Tanwar, S., Ganzha, M., Rodrigues, J.J.P.C. (eds) Proceedings of Second International Conference on Computing, Communications, and Cyber-

Security. Lecture Notes in Networks and Systems, vol 203. Springer, Singapore. 2021.

[7]. Zakrzewski, A.M.; Huang, A.Y.; Zubajlo, R.; Anthony, B.W. Real-time blood pressure estimation from force-measured ultrasound. IEEE Trans. Biomed. Eng.pp 65, 861, 2018.

[8]. Parasuraman, S.; Raveendran, R. Measurement of invasive blood pressure in rats. J. Pharmacol. Pharmacother. 3, 172-176, 2012.

[9] Pandya, S. *et al.* Precision Agriculture: Methodologies, Practices and Applications. In: Singh, P.K., Wierzchoń, S.T., Tanwar, S., Ganzha, M., Rodrigues, J.J.P.C. (eds) Proceedings of Second International Conference on Computing, Communications, and Cyber-Security. Lecture Notes in Networks and Systems, vol 203, 2021.

[10] Pandya, S. *et al.* (2021). Smart Aging Wellness Sensor Networks: A Near Real-Time Daily Activity Health Monitoring, Anomaly Detection and Alert System. In: Singh, P.K., Wierzchoń, S.T., Tanwar, S., Ganzha, M., Rodrigues, J.J.P.C. (eds) Proceedings of Second International Conference on Computing, Communications, and Cyber-Security. Lecture Notes in Networks and Systems, vol 203. Springer, Singapore. https://doi.org/10.1007/978-981-16-0733-2_1

[11]. Sebald,D.J.; Bahr, D.E.; Kahn, A.R. Narrowband auscultatory blood pressure measurement. IEEE Trans. Biomed. Eng, 49, PP1038–1044, 2002.

[12]. Awais, M., Ghayvat, H, Healthcare Professional in the Loop (HPIL): Classification of Standard and Oral Cancer-Causing Anomalous Regions of Oral Cavity Using Textural Analysis Techniqu in Autofluorescence Imaging. Sensors, 20, 5780, , 2020.

[13]Pandya, S., Sur, A. et.al, "Smart epidemic tunnel: IoT-based sensor-fusion assistive technology for COVID-19 disinfection", *International Journal of Pervasive Computing and Communications*, Vol. 18 No. 4, pp. 376-387, 2022.

[14]. Barot, V., Kapadia, V., & Pandya, S.,Enabled IoT Based Low Cost Air Quality Monitoring System with Power Consumption Optimization, Cybernetics and Information Technologies, Bulgarian Academy of Science, 20(2), PP122-1402020.

[15]Pandya, S.; Ghayvat, H.; Sur, A.; Awais, M.; Kotecha, K.; Saxena, S.; Jassal, N.; Pingale, G. Pollution Weather Prediction System: Smart Outdoor Pollution Monitoring and Prediction for Healthy Breathing and Living. *Sensors* , *20*, 5448, 2020.

[16]Kurhe, R.V., Sur, A., Pandiya, S. (2023). Live Temperature Monitoring: IoT-Based Automatic Sanitizer Dispenser and Temperature Detection Machine, proceedings of Third International Conference on Computing, Communications, and Cyber-Security. Lecture Notes in Networks and Systems, vol 421. Springer, Singapore. pp978-981, 2022.

[17]Ruppert, M.; Reith, M.W.; Widmann, J.H.; Lackner, C.K.; Kerkmann, R.; Schweiberer, L.; Peter, K. Checking for breathing: Evaluation of the diagnostic capability of emergency medical services personnel, physicians, medical students, and medical laypersons. Ann. Emerg. Med.Vol 34, pp720–729, 1999.

[18]. Abolfazl Mehbodniya, L. Arokia Jesu Prabhu, Julian L. Webber, Dilip Kumar Sharma, Pandya, Sharnil, Fetal Health Classification from Cardiotocographic Data Using Machine Learning, Expert Systems, Wiley, pp 345-349,2021

[19]. Pandya Sharnil, Sur, A, Solke, N, COVIDSAVIOUR: A Novel Sensor-Fusion and Deep

Learning-Based Framework for Virus Outbreaks, Frontiers in Public Health, p p 797-808 2021.

Dr. Anirban Sur is Professor working at Symbiosis Institute of Technology, Symbiosis International (Deemed University). He graduated in mechanical engineering with distinction from one of the premier institute of Maharashtra. He has received his master degree from Birla Institute of Technology, Mesra Ranchi with honours and Ph.D from Indian Institute of technology (IIT ISM Dhanbad) He has also received a National scholarship in high school. His research area is micro heat exchanger design, micro lattice structure and its application, sorption refrigeration like adsorption/ absorption refrigeration system, desiccant cooling. He has completed four projects funded by MSME India, National Institute for research and development in Defense Shipbuilding. He has published numbers of research papers in international, national journals and international national conferences.