Original Research

The Evolution Of Hemoglobin Measurement With Iot

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Abstract— The development and integration of Internet of Things technology in healthcare systems have opened up new possibilities for monitoring and managing the health and well-being of individuals outside of traditional medical institutions (Yin et al., 2016). This technology has been particularly advantageous for patients with chronic diseases and the elderly, as it allows for remote health monitoring and real-time clinical feedback. By leveraging IoT-enabled smart devices, healthcare providers can collect real-time patient data and transfer it for assessment or self-management. One specific area where IoT technology has shown promising potential is in the monitoring of hemoglobin levels. Hemoglobin is an important protein in the blood that carries oxygen to different parts of the body. Accurate monitoring of hemoglobin levels is crucial for diagnosing and managing various medical conditions, such as anemia and certain types of cancer.

Keywords: Smartphone app , Hgb level Monitor, image analysis Algorithm and IoT.

1. INTRODUCTION

Anemia is a common condition that affects over 30% of the global population. It is characterized by a decrease in the number of red blood cells or hemoglobin, which leads to a decrease in the oxygen-carrying capacity of the blood. Anemia can be caused by various factors, such as iron deficiency, chronic diseases, or genetic disorders. Monitoring hemoglobin levels is crucial for the diagnosis and management of anemia. Traditionally, this has been done through blood tests, which are invasive, time-consuming, and require frequent visits to the doctor. This can be a challenge for patients, especially those who live in remote areas or have limited access to healthcare facilities.

The IoT hemoglobin monitoring system is a network of interconnected devices and sensors that can measure and transmit hemoglobin levels to a central database. The system consists of three main components: the wearable device, the gateway, and the cloud server.

The wearable device is a small, non-invasive sensor that can be attached to the patient's finger or earlobe. It uses photoplethysmography (PPG) technology to measure the changes in blood volume and calculate the hemoglobin level. PPG is a simple and reliable method that uses light to measure the blood flow in the capillaries. The device also has a wireless module that allows it to connect to the gateway.

The gateway is a small device that acts as a bridge between the wearable device and the cloud server. It uses Bluetooth or Wi-Fi to connect to the wearable device and transmit the collected data to the cloud server. The gateway also has a display that shows the real-time hemoglobin level and alerts the user if it falls below a certain threshold.

The cloud server is the central component of the system. It receives the data from the gateway and stores it in a database. The server also has a user interface that allows healthcare professionals to access the data and monitor the patient's hemoglobin levels remotely. The server can also send notifications to the patient and their doctor if the hemoglobin level is abnormal.

The IoT hemoglobin monitoring system can be implemented in three phases: hardware development, software development, and integration.

Currently, the most common method for measuring hemoglobin levels is through a blood test, which involves drawing a blood sample and sending it to a laboratory for analysis. However, this method is invasive, time-consuming, and requires skilled personnel to perform the test. As a result, there has been a growing interest in developing non-invasive and real-time hemoglobin monitoring technology.

One of the current developments in this field is the use of pulse oximetry to measure hemoglobin levels. Pulse oximetry is a non-invasive method that measures the oxygen saturation in the blood by using a sensor placed on the fingertip. This technology has been widely used in hospitals and has been shown to be accurate in measuring hemoglobin levels. However, it is limited to measuring only the oxygen-carrying capacity of hemoglobin and not the actual hemoglobin levels.

Another emerging technology for hemoglobin monitoring is the use of near-infrared spectroscopy (NIRS). NIRS uses light in the near-infrared range to penetrate the skin and measure the absorption of light by hemoglobin. This method has been shown to accurately measure hemoglobin levels and has the potential for real-time monitoring. However, the technology is still in its early stages, and further research is needed to improve its accuracy and reliability.

A] **Challenges in Hemoglobin Monitoring Technology**

Despite the advancements in hemoglobin monitoring technology, there are still some challenges that need to be addressed. One of the main challenges is the accuracy of the measurements. Non-invasive methods, such as pulse oximetry and NIRS, are prone to errors due to factors such as skin pigmentation, motion artifacts, and ambient light interference. Therefore, further research is needed to improve the accuracy and reliability of these methods.

Another challenge is the cost of these technologies. Current non-invasive hemoglobin monitoring devices are expensive, making them inaccessible to many healthcare facilities, especially in developing countries. There is a need for more affordable devices that can be used in resource-limited settings.

B] **Hardware Development**

The first step in implementing the system is to develop the hardware components. This includes designing and manufacturing the wearable device and the gateway. The wearable device should be small, lightweight, and comfortable to wear. It should also have a long battery life to ensure continuous monitoring. The gateway should be compact and easy to use, with a display screen and wireless connectivity. Inthis research the ESP32 is used as the main controller to get the data from the sensor. The sensor used here is MAX30100 which is pulse oximeter sensor.

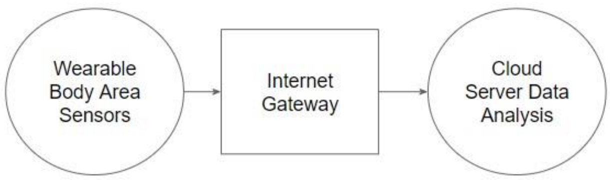

Fig 1 Architecture

As shown in Figure 1, the architecture of the IoWT and its connections consists of three elements: the WBAN, the gateway connected to the Internet, and the cloud. The WBAN is a front-end component of IoWT that wraps around the body to collect health-related data unnoticed. The WBAN collects data from sensors in direct contact with the body or from sensors in the environment that can collect indirect data about a person's behaviour. The WBAN can either analyze the data or transmit them for remote analysis. In addition, mobile computing devices such as smartphones, tablets, and laptops must be connected to the Internet to send data to powerful computing resources.

The ESP32 microcontroller has been widely used in various medical applications, including vital sign monitoring, remote patient monitoring, and telehealth. Its low-cost and low-power consumption make it suitable for developing portable and wearable devices for hemoglobin monitoring. Some potential applications of ESP32 in hemoglobin monitoring include:

1. Wearable devices: With the increasing popularity of wearable devices, there is a potential for developing a wearable device that can continuously monitor hemoglobin levels. The device could be worn on the fingertip or earlobe, similar to a pulse oximeter, and transmit real-time data to a smartphone or a cloud platform.
2. Point-of-care testing: The ESP32 microcontroller can be integrated into handheld devices for point-of-care testing. These devices could be used in remote areas or in emergency situations where access to laboratory facilities is limited.
3. Smart bandages: ESP32 can be used to develop smart bandages that can detect changes in hemoglobin levels in wounds. This technology can be useful in monitoring wound healing in patients with chronic wounds, such as diabetic foot ulcers.

C] **Literature Survey**

1 Non-Invasive Hemoglobin Monitoring Device

This paper deals with a non- invasive hemoglobin monitoring device that measures hemoglobin concentration of a person without utilizing a drop of blood. The method
proposed in this paper uses the principle of photoplethysmography and Beer Lambert law to measure the hemoglobin levels in blood. Two PPG signals are obtained by shining lights corresponding to Red and IR wavelengths on the fingertip of a person and absorbance levels are computed. Path length traveled by the light is determined using the refractive index of hemoglobin and the physical distance between source and detector. Using the two measured values with the known extinction coefficients, a relationship is derived to determine the hemoglobin concentration removing the need for any calibration. Discrete Kalman filter is designed to remove artifacts from the signal. The Arduino microcontroller board is used for signal acquisition and data is transferred via serial communication to PC for further analysis.

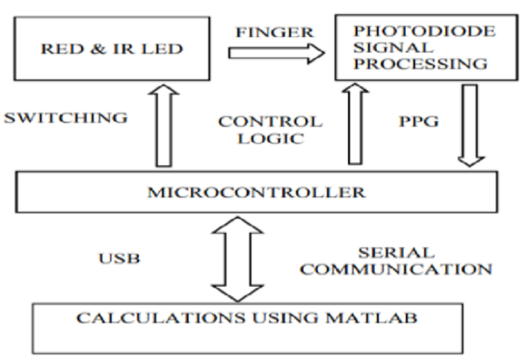

Fig 2 System diagram

2 HemoSmart: A Non-invasive, Machine Learning Based Device and Mobile App for Anemia Detection

This paper presents a non-invasive method to detect Anemia (a low level of Hemoglobin)easily. The Hemoglobin concentration in human blood is an important substance to health condition determination. With the results which are obtained from the Hemoglobin test, a condition which is called Anemia can be revealed. Traditionally the Hemoglobin test is done using blood samples which are taken using needles. The non-invasive Hemoglobin measurement system, discussed in this paper, describes a better idea about the hemoglobin concentration in the human blood. The images of the finger- tip of the different hemoglobin level patients which are taken using a camera are used to develop the neural network-based algorithm. The pre-mentioned algorithm is used in the developed non invasive device to display the Hemoglobin level. Before doing the above procedure, an account is created in the cloud server and a questionnaire is given to answer by the patient. Finally, both the results which are obtained from the mobile app and the device are run through a machine learning algorithm to get the final output. According to the result, the patient would be able to detect anemia at an early stage.

3 A Novel Non-invasive Hemoglobin Sensing Device for Anemia Screening

In this paper, we present the architecture and development of such a device. Using a specific arrangement of light emitting diodes and fiber optics, we have created a novel multiwavelength spectrophotometric sensing platform to detect anemia. A mechanical lever operated fiber optics based sensor eliminates the problems associated with conventional noninvasive finger probe, aiding in the detection of hemoglobin levels as low as 1.6 g/dL.

This study also proposes a method wherein incident light intensity can be measured along with attenuated light intensity to support hemoglobin estimation. The device could detect the light signals as low as 0.001% of the incident light intensity. Performance of the proposed platform was validated in conjunction with an algorithm to estimate hemoglobin. The device was able to estimate hemoglobin with an RMSE of 1.47 ± 0.042 g/Dl and a correlation of 0.79 ± 0.03 between the predicted and actual value of Hb.

4 A Novel Real-Time Non-Invasive Hemoglobin Level Detection Using Video. Images from Smartphone Camera

In this paper, we present a smartphone-based non-invasive hemoglobin detection method.It uses the video images collected from the fingertip of a person. We hypothesized that there is a significant relation between the fingertip mini-video images and the hemoglobin level by laboratory" gold standard."

5 Non-invasiveHemoglobin Measurement for Anemia Diagnosis

-Hemoglobin is an important part of the red blood cell to transport oxygen and carbon dioxide. Hemoglobin concentration in the blood can be used as a physical condition parameter. A low hemoglobin level is called anemia and high hemoglobin level is called polycythemia. WHO has determined the anemia cut off level of hemoglobin concentration based on age, sex, and condition (pregnant or not).Currently, accurate and reliable hemoglobin concentration measurement uses invasive methods such as cyanmethemoglobin and automated hematology analyzer. But these methods are expensive, not real time, high infection risk, and need special techniques. Non-invasive methods offer a better alternative because it has low infection risk, instant result, and portable in size. This work developed a non-invasive hemoglobin measurement for anemia diagnosis based on optical spectroscopy. The system utilized LED and photodiode as optical sensor placed on the fingertip. Photodiode just could obtain

DC component, so the signal conditioning circuit which consisted of HPF, LPF and amplifier was used to obtain the AC component of the signal. This system used a microcontroller to control the operation of the hardware and to calculate the hemoglobin concentration.

The IoT hemoglobin monitoring system offers several benefits compared to traditional methods of monitoring hemoglobin levels. First and foremost, it is non-invasive, making it more comfortable for patients, especially children and the elderly. It also eliminates the need for frequent visits to the doctor, as the system can continuously monitor the hemoglobin levels and alert the patient and their doctor if there is any abnormality. This can save time and reduce healthcare costs for patients. Moreover, the system can be used in remote areas where access to healthcare facilities is limited, improving the quality of healthcare for underserved populations.

D] **Block Diagram for the system**

As per the research study the the below block diagram the ESP32 the wifi based controller and having and which the

includes temperature MAX31011 sensor display Hemoglobin level on OLED as well as the data of the sensor send to the cloud server my sql database where the parameters will show in the form of graph.

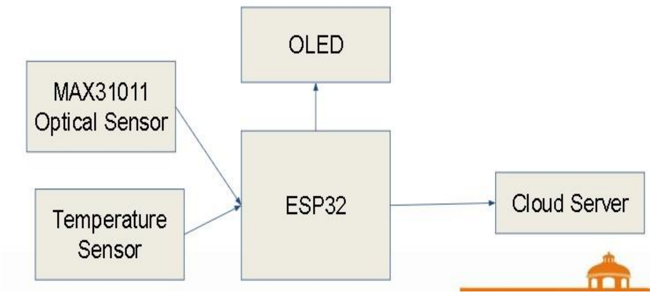

Fig 3 Block Diagram

Pulse oximetry is based on the principle that the amount of RED and IR light absorbed varies depending on the amount of oxygen in your blood. The following graph is the absorption-spectrum of oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin (Hb).deoxygenated blood absorbs more RED light (660nm), while oxygenated blood absorbs more IR light (880nm)

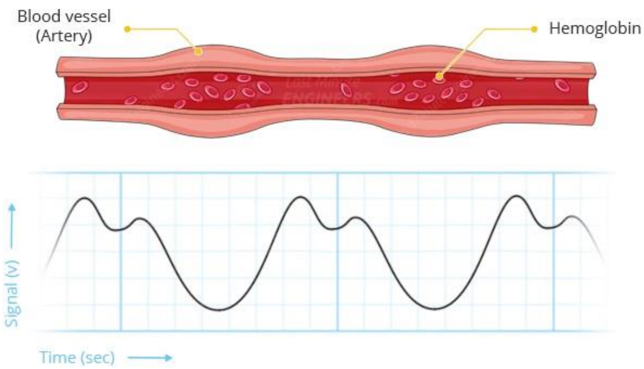

Fig 4 Blood flow detector

E] Hardware of Healthcare Monitoring System

In this research is based on the Non invasive method for detecting Hemoglobin level Here the Oxymeter sensor is used that works on the principle of IR rays and IR detector.The oxygenated hemoglobin (HbO2) in the arterial blood has the characteristic of absorbing IR light. The redder the blood (the higher the hemoglobin), the more IR light is absorbed.As the blood is pumped through the finger with each heartbeat, the amount of reflected light changes, creating a changing waveform at the output of the photodetector.This sensed data willsend on the cloud server database to monitor data online

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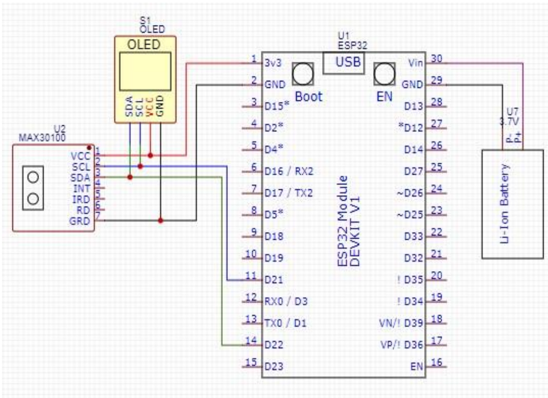

Fig 5 Circuit Diagram

Here the main controller is ESP32 and for the detection of the parameters MAX30100 sensor is used. The data will display on OLED and same will send to the cloud server for the analysis

F] Cloud server

Cloud storage is a model of computer data storage in which the digital data is stored in logical pools. The physical storage spans multiple servers (sometimes in multiple locations), and the physical environment is typically owned and managed by a hosting company. These cloud storage providers are responsible for keeping the data available and accessible, and the physical environment protected and running. People and organizations buy or lease storage capacity from the providers to store user, organization, or application data.

Cloud storage services may be accessed through a colocated cloud computing service, a web service application programming interface (API) or by applications that utilize the API, such as cloud desktop storage, a cloud storage gateway or Web-based content management systems.

Cloud storage is based on highly virtualized infrastructure and is like broader cloud computing in terms of accessible interfaces, near-instant elasticity and scalability, multi-tenancy, and metered resources. Cloud storage services can be utilized from an off-premises service (Amazon S3) or deployed on-premises (ViON Capacity Services).

Cloud storage typically refers to a hosted object storage service, but the term has broadened to include other types of data storage that are now available as a service, like block storage.

Object storage services like Amazon S3, Oracle Cloud Storage and Microsoft Azure Storage, object storage software like Openstack Swift, object storage systems like EMC Atmos, EMC ECS and Hitachi Content Platform, and distributed storage research projects like OceanStore and VISION Cloud are all examples of storage that can be hosted and deployed with cloud storage characteristics

For our project we use 000webhost.com as free web cloud server

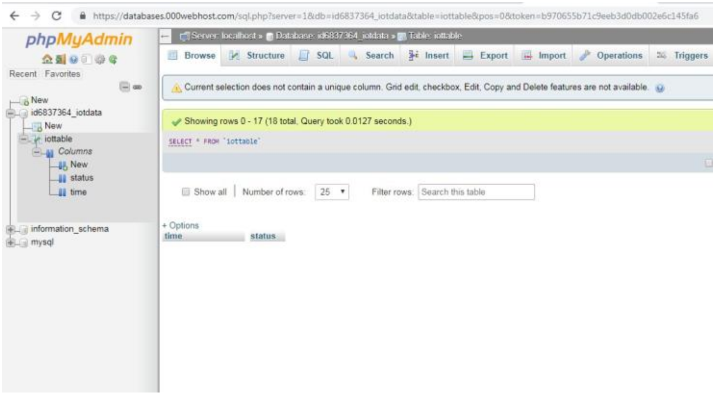

Fig 6 MySQl Dataabse

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5. Conclusion

In conclusion, the design and implementation of an IoT hemoglobin monitoring system have the potential to transform the way anemia is managed. The system offers a non-invasive and convenient way to monitor hemoglobin levels, improving the quality of life for patients. It also allows for remote monitoring and early detection of abnormalities, which can lead to better healthcare outcomes. However, further research and development are needed to refine the system and make it more accessible and affordable for patients. The ESP32 microcontroller has the potential to revolutionize this field with its low-cost and low-power consumption. Current developments, such as pulse oximetry and NIRS, have shown promising results, but further research is needed to improve their accuracy and reliability. Addressing the challenges, such as cost and accuracy, can lead to the development of more accessible and accurate devices for hemoglobin monitoring. With the potential applications of ESP32 in this field, the future of hemoglobin monitoring technology looks promising, and it has the potential to improve the diagnosis and management of various medical conditions.

6. Reference

1. Farhan L., Hameed R.S., Ahmed A.S., Fadel A.H., Gheth W., Alzubaidi L., Fadhel M.A., Al-Amidie M. Energy Efficiency for Green Internet of Things (IoT) Networks: A Survey. *Network.* 2021;1:279– 314. doi: 10.3390/network1030017.
2. Alekya R., Boddeti N.D., Monica K.S., Prabha R., Venkatesh V. IoT based smart healthcare monitoring systems: A literature review. *Eur. J. Mol. Clin. Med.* 2021;7:2020
3. Naveen, Sharma R.K., Nair A.R. IoT-based Secure Healthcare Monitoring System; Proceedings of the 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT); Coimbatore, India. 20–22 February 2019; pp. 1–6.
4. Rathi V.K., Rajput N.K., Mishra S., Grover B.A., Tiwari P., Jaiswal A.K., Hossain M.S. An edge AI-enabled IoT healthcare monitoring system for smart cities. *Comput. Electr. Eng.* 2021;96:107524. doi: 10.1016/j.compeleceng.2021.107524
5. Alshamrani M. IoT and artificial intelligence implementations for remote healthcare monitoring systems: A survey. *J. King Saud Univ. Comput.Inf.Sci.* 2022;34:4687–4701. doi: 10.1016/j.jksuci.2021.06.005.
6. Gera S., Mridul M., Sharma S. IoT based Automated Health Care Monitoring System for Smart City; Proceedings of the 2021 5th International Conference on Computing Methodologies and Communication (ICCMC); Erode, India. 8–10 April 2021; pp. 364– 368.
7. Bhatia H., Panda S.N., Nagpal D. Internet of Things and its Applications in Healthcare—A Survey; Proceedings of the 2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO); Noida, India. 4–5 June 2020.

8. Jain U., Gumber A., Ajitha D., Rajini G., Subramanian B. A Review on a Secure IoT-Based Healthcare System; Proceedings of the Advances in Automation, Signal Processing, Instrumentation, and Control: Select Proceedings of i-CASIC; India. 27–28 February 2020; pp.
9. Kumar R., Rajasekaran M.P. An IoT based patient monitoring system using raspberry Pi; Proceedings of the 2016 International Conference on Computing Technologies and Intelligent Data Engineering (ICCTIDE'16); Kovilpatti, India. 7–9 January 2016; pp. 1–4
10. 10. Meliá S., Nasabeh S., Luján-Mora S., Cachero C. MoSIoT: Modeling and Simulating IoT Healthcare-Monitoring Systems for People with Disabilities. *Int. J. Environ. Res. Public Health.* 2021;18:6357. doi: 10.3390/ijerph18126357.
11. Philip N.Y., Rodrigues J.J.P.C., Wang H., Fong S.J., Chen J. Internet of Things for In-Home Health Monitoring Systems: Current Advances, Challenges and Future Directions. *IEEE J. Sel. AreasCommun.*2021;39:300–310.doi: 10.1109/JSAC.2020.3042421.
12. Bhardwaj R., Gupta S.N., Gupta M., Tiwari P. IoT based Healthware and Healthcare Monitoring System in India;
13. Proceedings of the 2021 International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE); Greater Noida, India. 4–5 March 2021; pp. 406–408.
14. Patel W.D., Patel C., Valderrama C. IoMT based Efficient Vital Signs Monitoring System for Elderly Healthcare Using Neural Network. *Int. J. Res.* 2019;VIII:239.
15. Li C., Hu X., Zhang L. The IoT-based heart disease monitoring system for pervasive healthcare service. *Procedia Comput. Sci.* 2017;112:2328–2334. doi: 10.1016/j.procs.2017.08.265.
16. Cao H.-R., Zhan C. A Novel Emergency Healthcare System for Elderly Community in Outdoor Environment. *Wirel. Commun. Mob. Comput.* 2018;2018:7841026. doi: 10.1155/2018/7841026.
17. Wu T., Wu F., Qiu C., Redouté J.M., Yuce M.R. A Rigid-Flex Wearable Health Monitoring Sensor Patch for IoT-Connected HealthcareApplications. *IEEE Internet Things J.* 2020;7:6932–6945. doi: 10.1109/JIOT.2020.2977164.
18. Islam M.M., Rahaman A., Islam M.R. Development of smart healthcare monitoring system in IoT environment. *SN Comput. Sci.* 2020;1:1–11. doi: 10.1007/s42979-020-00195-y.
19. Al-Sheikh M.A., Ameen I.A. Design of mobile healthcare monitoring system using IoT technology and cloud computing; Proceedings of the IOP Conference Series: Materials Science and Engineering; Baghdad, Iraq. 15 April 2020; p. 012113.
20. Hamim M., Paul S., Hoque S.I., Rahman M.N., Baqee I. IoT
21. Based Remote Health Monitoring System for Patients and Elderly People; Proceedings of the 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST); Dhaka, Bangladesh. 10–12 January 2019; pp. 533–538.
22. Swaroop K.N., Chandu K., Gorrepotu R., Deb S. A health monitoring system for vital signs using IoT. *Internet Things.* 2019;5:116–129. doi: 10.1016/j.iot.2019.01.004.
23. Gupta D., Parikh A., Swarnalatha R. Integrated healthcare monitoring device for obese adults using internet of things (IoT) *Int. J. Electr. Comput. Eng.* 2020;10:1239–1247.doi: 10.11591/ijece.v10i2.pp1239- 1247.
24. Alamsyah M.S., Ikhlayel M., Setijadi E. Internet of things–based vital sign monitoring system. *Int. J. Electr. Comput. Eng.* 2020;10:5891– 5898. doi: 10.11591/ijece.v10i6.pp5891-5898.
25. K. S. Pavithra, X. Anitha Mary, K. Rajasekaran, and R. Jegan, "Low Cost Non-Invasive Medical Device for Measuring Hemoglobin," Proc. IEEE Int. Conf. Innov. Electr. Electron. Instrum. Media Technol. ICIEEIMT 2017, vol. 2017-Janua, pp. 197–200, 2017.