

BREATHING SENSOR WITH SLEEPING PATTERN ANALYSIS

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Technology degree in BIOMEDICAL ENGINEERING

by

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INTERDISCIPLINARY PROJECT REPORT
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SCHOOL OF BIO AND CHEMICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Interdisciplinary Project Report is the bonafide work of **Akshara s (39240006)** , **Renitta D (39240031)** who carried out the Inter disciplinary project entitled **"BREATHING SENSOR WITH SLEEPING PATTERN ANALYSIS"** under our supervision from **December 2021 to April 2022**.

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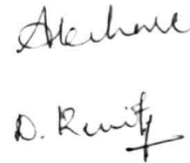
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DECLARATION

We **AKSHARA S, RENITTA D** hereby declare that the Interdisciplinary Project Report entitled “**BREATHING SENSOR WITH SLEEPING PATTERN ANALYSIS**” done by us under the guidance of **Dr. J. PremKumarat** Department of Biomedical Engineering, Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of **Bachelor of Technology** degree in **Biomedical Engineering**.

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The block contains two handwritten signatures. The top signature is 'Akshara' written in a cursive script. The bottom signature is 'D. Renitta' also in a cursive script.

SIGNATURE OF THE CANDIDATE

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LIST OF ABBREVIATION

ABBREVIATION	EXPANSION
OSA	Obstructive Sleep Apnea
SA	Sleep apnea
BP	Blood Pressure
HR	Heart Rate
PCG	Photoplethysmography
LED	Light emitting diode
AC	Alternating current
DC	Direct current
SVM	Support vector machine
IR	Infrared sensor
UV	Ultra violet
IOS	iPhone OS

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ABSTRACT

Sleep apnea is a disorder caused by the insistent collapse of upper airway during sleep where the breathing is continuous stopped. This disorder is usually diagnosed and tested using polysomnography in a laboratory. However, this method is costly, inconvenient, time consuming so it cannot be moved from lab. There are several methods suggested to analysis at patient's home by using different sensors to detect physiological signals that automatically analyses the specific algorithms. The purpose of this study was to explore works related to SA in such a way that highlights methods of detection. The researcher compared between the accuracy, sensitivity, specificity of SA detection and prediction. This review was conducted to provide information for the researchers who want to implement algorithms for detection of sleep apnea event (SAE).

CHAPTER- 1

INTRODUCTION

Every human requires a minimum of eight hours of sleep per night. Obstructive sleep apnea is caused by the frequent obstruction of the upper airway passage while sleeping. The major causes of the sleep apnea depend on an individual's medical condition and the physiological structure. Obesity, premature birth, depression, genetic syndromes, large tonsils are the common causes of the sleep apnea disorder. The unhealthy lifestyle habits like drinking, smoking, unhealthy food diets and eating patterns increase the risk for sleep apnea. The age and gene history also plays major role in risks for sleep apnea. If the sleep apnea is left untreated it may also lead to greater risk of heart failure, stroke, coronary heart disease, high blood pressure, type 2 diabetes, adult asthma etc., The estimation of the sleep apnea disease prevalence is at a range of 3% to 7% where in India alone it is estimated as 3.4 % to 4.96 %, men face this problem more than that of the women. The usual approach for diagnosing sleep apnea is polysomnography, which involves observing and recording the sleep events of sleep apnea patients in a supervised sleep clinic. The portable sleep apnea monitors are devices used currently in the diagnosis. This paper describes the design of a wearable smart watch that uses three parameters to diagnose sleep apnea events: heart rate, blood oxygen saturation level, and blood pressure. The heart rate and blood oxygen saturation level are measured using sensors, while the blood pressure is measured using a cuff-less method. A sleep apnea epoch classification is performed using the single lead ECG and these sensor signals are sent to the app developed for the smart phone where the further signal processing and diagnosis is done. The aim of the study was to continuously monitor the OSA patients using developed prototype device. The ultimate objective of this study focuses on the detection of heart rate, oxygen saturation level and cuff-less blood pressure for the sleep apnea disorder and normal subjects.

CHAPTER- 2

LITERATURE SURVEY

- 1) Heart Rate data collecting using Smart Watch: R. Wijaya, Ary Setijadi, Tati L Mengko, Richard KL Mengko (2014) Data collecting is important issue for health care problem. Many people are used heart rate for identify how much calories burned. Heart rate data is collected using direct observation method. Direct observation method using tools calls smart watch. This data is used for further research in heart rate time series.

- 2) Obstructive Sleep Apnea Detection: X Wang, M Cheng, Y Wang, S Liu, Z Tian (2020) Sleep medicine has been an expanding discipline during the last few decades. The prevalence of sleep disorders is increasing, and sleep centers are expanding in hospitals and in the private care environment to meet the demands. Sleep medicine has evidence-based guidelines for the diagnosis and treatment of sleep disorders. However, the number of sleep centers and caregivers in this area is not sufficient. Many new methods for recording sleep and diagnosing sleep disorders have been developed. Many sleep disorders are chronic conditions and require continuous treatment and monitoring of therapy success. Cost-efficient technologies for the initial diagnosis and for follow-up monitoring of treatment are important. It is precisely here that telemedicine technologies can meet the demands of diagnosis and therapy follow-up studies. Wireless recording of sleep and related bio signals allows diagnostic tools and therapy follow-up to be widely and remotely available. Moreover, sleep research requires new technologies to investigate underlying mechanisms in the regulation of sleep-in order to better understand the pathophysiology of sleep disorders. Home recording and non-obtrusive recording over extended periods of time with telemedicine methods support this research. Telemedicine allows recording with little subject interference under normal and experimental life conditions.

- 3) Apnea detector with Smart Watches: Xianda Chen, Yifei Xiao, Yeming Tang, Julio Fernandez-Mendoza, Guohong Cao (2021) Sleep apnea is a sleep disorder in which breathing is briefly and repeatedly interrupted. Polysomnography (PSG) is the standard clinical test for diagnosing sleep apnea. However, it is expensive and time-consuming which requires hospital visits, specialized wearable sensors, professional installations, and long waiting lists. To address this problem, we design a smartwatch-based system called Apnea Detector, which exploits the built-in sensors in smartwatches to detect sleep apnea. Through a clinical study, we identify features of sleep apnea captured by smartwatch, which can be leveraged by machine learning techniques for sleep apnea detection. However, there are many technical challenges such as how to extract various special patterns from the noisy and multi-axis sensing data. To address these challenges, we propose signal denoising and data calibration techniques to process the noisy data while preserving the peaks and troughs which reflect the possible apnea events. We identify the characteristics of sleep apnea such as signal spikes which can be captured by smartwatch, and propose methods to extract proper features to train machine learning models for apnea detection. Through extensive experimental evaluations, we demonstrate that our system can detect apnea events with high precision (0.9674), recall (0.9625), and F1-score (0.9649).
- 4) Technology to access Sleep Apnea: mas Penzel, Christoph Schöbel, Ingo Fietze (2018) Sleep medicine has been an expanding discipline during the last few decades. The prevalence of sleep disorders is increasing, and sleep centers are expanding in hospitals and in the private care environment to meet the demands. Sleep medicine has evidence-based guidelines for the diagnosis and treatment of sleep disorders. However, the number of sleep centers and caregivers in this area is not sufficient. Many new methods for recording sleep and diagnosing sleep disorders have been developed. Many sleep disorders are chronic conditions and require continuous treatment and monitoring of therapy success. Cost-efficient technologies for the initial diagnosis and for follow-up monitoring of treatment is important. It is precisely here that telemedicine technologies can meet the demands of diagnosis and therapy follow-up studies. Wireless recording of sleep and related bio signals allows diagnostic tools and therapy follow-up to be widely

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- 5) Capturing Rich sleep information using Smart Watch: Liqiong Chang, Jiaqi Lu, Ju Wang, Xiaojiang Chen, Dingyi Fang, Zhanyong Tang, Petteri Nurmi, Zheng Wang (2018) Sleep is an important part of our daily routine -- we spend about one-third of our time doing it. By tracking sleep-related events and activities, sleep monitoring provides decision support to help us understand sleep quality and causes of poor sleep. Wearable devices provide a new way for sleep monitoring, allowing us to monitor sleep from the comfort of our own home. However, existing solutions do not take full advantage of the rich sensor data provided by these devices. In this paper, we present the design and development of Sleep Guard, a novel approach to track a wide range of sleep-related events using smartwatches. We show that using merely a single smartwatch, it is possible to capture a rich amount of information about sleep events and sleeping context, including body posture and movements, acoustic events, and illumination conditions. We demonstrate that through these events it is possible to estimate sleep quality and identify factors affecting it most. We evaluate our approach by conducting extensive experiments involved fifteen users across a 2-week period. Our experimental results show that our approach can track a richer set of sleep events, provide better decision support for evaluating sleep quality, and help to identify causes for sleep problems compared to prior work.
- 6) Fenet: A frequency extraction network for obstructive sleep apnea detection: Guanhua Ye, Hongzhi Yin, Tong Chen, Hongxu Chen, Lizhen Cui, Xiangliang Zhang (2021) To accomplish OSA detection in an energy-efficient manner, a unique model extracts features from different frequencies of the input RR-interval signals. We created a dilated

convolutional neural network with a dilated convolutional neural network with a dilated convolutional neural network with a collection of filters for various frequency bands as a result, Fenet Adapts to frequencies that are near to human breath and responds appropriately produces an expressive portrayal of a breathing epoch. After that, one convolutional neural network processes the representation. To build a layer block and three fully connected layer blocks final detection findings for the present epoch as well Epoch from neighboring epochs, we would like to continue our work in the future. Incorporating a human-in-the-loop scheme into Fenet is something I'd like to do make it capable of making correct predictions in a timely manner.

- 7) Sleep monitor: Monitoring respiratory rate and body position during sleep using smart watch: Xiao Sun, Li Qiu, Yibo Wu, Yeming Tang, Guohong Cao (2017) We create a multi-axis fusion method that can adaptively alter the estimations from the three axes and so enhance estimation accuracy dramatically. We use machine learning approaches based on attributes taken from accelerometer data to detect body position. We tested our solution on Android Wear wearables and evaluated its performance in real-world scenarios. The findings reveal that our technology can accurately monitor respiratory rate and body position during sleep under a variety of situations.
- 8) Watch- PAT Is useful in the diagnosis of Sleep apnea in patients with Atrial Fibrillation: Riva Tauman, Murray Berall, Richard Berry, Prashanth Manthena, Anil Rama, Rebecca Spiegel., (2020) Participants were gathered as part of a wider study that took place at 11 different medical centers. PSG and WP200U were performed simultaneously in the lab. The PSG was manually scored by an experienced PSG technologist who was blinded to the WP's automatic scoring methodology. The WP signals were examined with the help of the company's automated software. The results of the human PSG scoring analysis were compared to the WP automated scoring analysis.

- 9)** Relationship between Snoring Intensity and Severity of Obstructive Sleep Apnea: Jeong-Whun Kim, Chul Hee Lee, Chae Seo Rhee and Ji- Hun Mo (2015) This study comprised 404 patients (338 men and 66 females) who had a home-based portable sleep study for obstructive sleep apnea (OSA) using the Watch-PAT 100 from January 2009 to December 2011. The participants were separated into four groups: those with no OSA (PAT apnea hypopnea index), mild OSA, moderate OSA, and severe OSA. The Watch-PAT 100 was used to evaluate mean snoring intensity and percent sleep time with snoring intensity greater than 40, 50, and 60 db. These characteristics were compared to the apnea hypopnea index (AHI), the respiratory disturbance index (RDI), and the oxygen desaturation index.
- 10)** Quantitative detection of sleep apnea with wearable watch device: Junichiro Hayano, Hiroaki Yamamoto, Izumi Nonaka., (2020) Subjects visited a sleep clinic in the evening and spent overnight in a PSG testing chamber equipped with an Alice diagnostic sleep system (Philips Respironics, Murrysville, PA, USA). During the PSG, they wore a wearable watch device (E4 wristband, Empatica, Milano, Italy) on their left wrist and made a continuous recording of the PPG.

CHAPTER- 3

AIM AND SCOPE

3.1 AIM:

- Detects sleeping disorder.
- Fixed trouble in breathing and also it tracks heart rate, blood pressure, oxygen level in blood.
- Summarizes recent developments in the field of wearable sensors and systems that are relevant to the field of rehabilitation.
- Wearable sensors are used.

3.2 SCOPE:

- This has concern on blood pressure, heart rate and oxygen level in the blood.
- This device is wearable and easy to handle.
- Also, the patient can directly link to the Doctor to track the activities.

CHAPTER-4

MATERIALS AND METHODS

4.1 METHODOLOGY:

- This sleep apnea smart watch is designed to be the wearable for the continuous monitoring and information gathering system. We use oxygen saturation level, heart rate and the blood pressure which is obtained using the cuff less and non-invasive method.
- And we use SVM classifier to classify normal from sleep apnea subjects and the obtained data from the subjects are given in three different types of classifiers like SVM, navies base and, multilayer perceptron in order to differentiate subjects and through employing these three different types of classifiers we could know the best classifier for the classification of normal from abnormal subjects.

4.1.1 BLOCK DIAGRAM WITH EXPLANATION

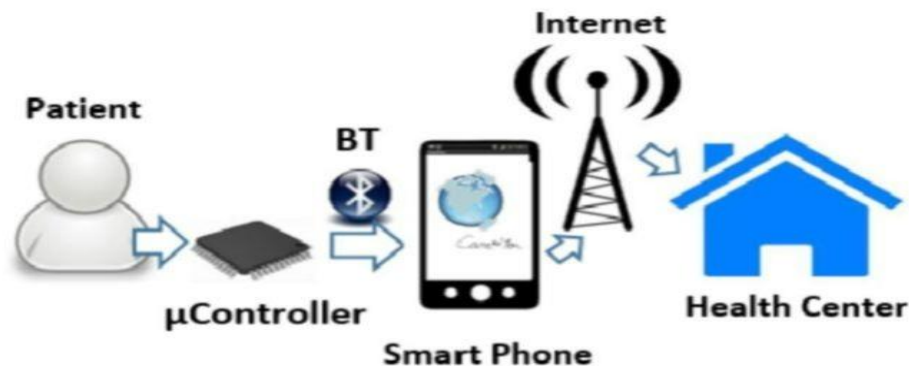


FIG 4.1.1 BLOCK DIAGRAM WITH EXPLANATION

The sleep apnea smart watch is design to be the wearable for the continuous monitoring and information gathering system for the diagnostic purpose. We utilize the certain physiological parameters like blood pressure, blood oxygen saturation level and heart rate which are acquired using sensors and processed using microcontroller. And we use SVM classifier to classify normal from sleep apnea subjects whereas the existing sleep apnea device uses different relevant parameters for the monitoring purpose and they may require quite considerable area for the respective device. The design and fabrication of our entire proposed system performs the data and results that we have obtained and listed above. Tingyu Sheng et al explains about the diagnosis of sleep apnea using wearable wrist watch by using different parameters like blood oxygen level, respiratory flow, breathing movement. Here in our device, we have used blood saturation level sensor to find the percentage of spo2 which indicates the sleep apnea event. We explain about the cuff less means of measuring the blood pressure in real time. The acquired observations are sent through the Bluetooth. The algorithm developed for the device provides the measurements through the analytical calculation.

4.2 HARDWARE USED:

4.2.1 MAX 30100

- The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals.
- Our analysis shows the accuracy rate of the Max30100 measurement is 97.11% and 98.84%, for heart rate and oxygen saturation (SpO2), respectively. Bland Altman was used to appraising and visualizing the agreement between the two measurement devices.



FIG 4.2.1 MAX30100

4.3 SOFTWARES USED

4.3.1 HWO1

- The function Step Is to Count, Heart Rate Monitoring, Calories Burned, Sleep Tracking, Distance Traveled, Notification.
- The indicator type is vibration.
- Compatible with both IOS and Android

4.3.2 LED

When electricity travels through a light-emitting diode (LED), it produces light. Photons are produced when electrons in a semiconductor recombine with electron holes, releasing energy. The energy required for electrons to pass the semiconductor's bandgap determines the hue of light (equivalent to photon energy). Multiple semiconductors or a light-emitting phosphor layer on the semiconductor device are used to generate white light. LEDs originally debuted as working electrical components in 1962, emitting low-intensity infrared (IR) light. Infrared LEDs

are employed in remote-control circuits, which are used in a broad variety of consumer electronics. The first visible-light LEDs were low-intensity and only came in red. Early LEDs were extensively used as indicator lamps and in seven-segment displays, where they replaced small incandescent bulbs. LEDs in visible, ultraviolet (UV), and infrared wavelengths have lately been produced with high, low, or intermediate light output, such as white LEDs excellent for room and outdoor area illumination. LEDs have also given rise to new types of displays and sensors, and their fast-switching rates are useful in advanced communications technology, with applications ranging from aviation lighting to fairy lights, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, lighted wallpaper, horticultural grow lights, and medical devices. LEDs outperform incandescent light sources in several ways, including lower power consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. LEDs have electrical limitations to low voltage and generally DC (not AC) power, the inability to provide steady illumination from a pulsing DC or an AC electrical supply source, and lower maximum operating temperature and storage temperature in exchange for these generally favorable characteristics. Unlike LEDs, incandescent lamps may be constructed to operate at virtually any source voltage, can use AC or DC interchangeably, and can deliver steady illumination at frequencies as low as 50 Hz whether driven by AC or pulsating DC. While an incandescent bulb may and frequently does function directly from an unregulated DC or AC power supply, LEDs frequently require the usage of electrical support components.

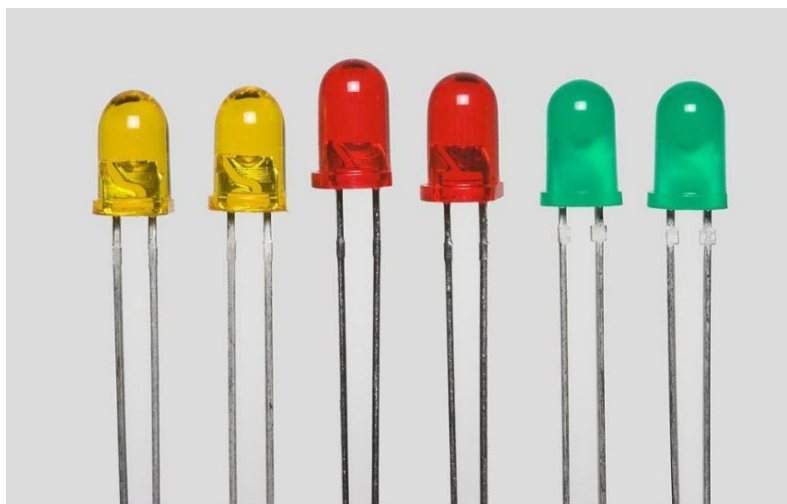


FIG 4.3.2 LED

4.4 OTHER COMPONENTS USED

4.4.1 SMART PHONES

To determine if a person is experiencing sleep apnea events, Apnea App transforms an Android smartphone into an active sonar system that tracks tiny changes in a person's breathing movements.

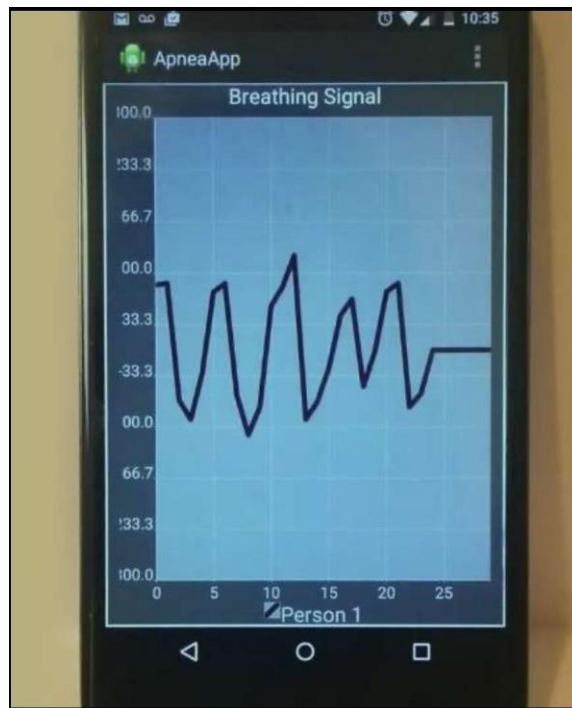


FIG 4.4.1 SMARTPHONE

4.4.2 HEART RATE MONITOR

Heart rate slowed 9.5 beats per minute (bpm) during apneas of 10-19 s in duration, 11.4 bpm during 20-39s apneas, and 16.6 bpm during 40-59-s apneas. Sleep stage had no effect unexplained by apnea length or degree of desaturation.

Cardiovascular changes accompany every single apnea event. With each apnea heart rate decreases. During the apnea we do see a relative bradycardia. After the end of the apnea, when respiration reconstitutes a relative tachycardia is observed.



FIG 4.4.2 HEART RATE MONITOR IN SMART WATCH

4.4.3 BP SENSOR

Cuffless BP monitor is used to detect the blood pressure. When you periodically stop breathing in your sleep, your body releases stress hormones. The American Heart Association explains that, with obstructive sleep apnea, these hormones can lead to high blood pressure, stroke, and heart disease. It's in accordance with the heart rate. Cuffless method is used so that it doesn't hurt the skin.



FIG 4.4.3 CUFFLESS BP MONITOR

CHAPTER-5

RESULT AND DISCUSSION

5.1 RESULT

- This sleep apnea smart watch is intended to be worn as part of a continuous monitoring and information collection system.
- We use oxygen saturation, heart rate, and blood pressure, which are all measured without the use of a cuff and in a non-invasive manner.
- And we use SVM classifier to classify normal from sleep apnea subjects, and the obtained data from the subjects is given in three different types of classifiers, such as SVM, navies base, and multilayer perceptron, in order to differentiate subjects, and by employing these three different types of classifiers, we can determine which classifier is the best for the classification of normal from abnormal subjects.
- Existing sleep apnea devices use a variety of relevant parameters for monitoring purposes, and they can take up a lot of space.



FIG 5.1 SMART WATCH

5.2 DISCUSSION

The section provides a review of applications of ambient sensors and systems used in this project. According to the review of this project, we came to know that the HR, BP and o2 level in the blood are determined.

CHAPTER- 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

This sleep apnea smart watch is designed to be the wearable for the continuous monitoring and information gathering system. We use oxygen saturation level, heart rate and the blood pressure which is obtained using the cuff less and non-invasive method. We use SVM classifier to classify normal from sleep apnea subject and the obtained data from the subjects are given in three different types of classifiers like SVM, navies base and, multilayer perceptron in order to differentiate subjects and through employing these three different types of classifiers we could know the best classifier. The existing sleep apnea device uses different relevant parameters for the monitoring purpose and they may require quite considerable area for the respective device.

6.2 CONCLUSION

In this study, we provide a wearable continuous sleep apnea monitoring system that can measure spo2, heart rate, and blood pressure in real time without the use of a cuff, and so avoids the complications of other portable sleep apnea devices. The observational values obtained by our device demonstrate a good level of consistency with polysomnography methodological results, bringing sleep apnea monitoring to wrist-based wearables in a cost-effective and power-efficient manner. This broadens the breadth of sleep apnea syndrome screening, which can also be employed in the therapy analysis process.

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