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*RESEARCH ARTICLE*

# YELLOW LIGHT THE NEXT TECHNOLOGY FOR SMART WATCHES

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***Abstract***

Light emitting diodes (LED) are often found in wearable smart electronic devices, such as smart watches, health care monitoring system etc. These are utilized for photoplethysmography (PPG) to monitor a variety of physical health factors. Wearable health monitoring systems have been developed as an outcome of the growth of sensor-based process to deliver real-time feedback information to promote health. This technique has the potential to help with symptom checking and treatment in sophisticated diseases, such as pain management.



## Introduction:-

Lightemitting diodes (LED) are often found in wearable smart electronic devices, such as smart watches, health care monitoring system etc.These are utilized for photoplethysmography (PPG) to monitor a variety of physical health factors. Wearable health monitoring systems have been developed as anoutcome of the growth of sensor-based process to deliver real-time feedback information to promote health. This technique has the potential to help with symptom checking and treatment in sophisticated diseases, such as pain management.

Wearable technologies and accompanying applications that can undoubtedly aid in the management of health and illness in the future of healthcare. The challenge for physicians and computer scientists is to form collaborative relationships in order to better understand the requirements and possibilities that exist[1].Invasive catheterization or non-invasive cuff-based procedures are used to test blood pressure (BP). The invasive approach measures arterial pressure by introducing a catheter with a BP sensor directly into the blood artery or heart. Because invasive BP measurement is continuous and precise, and it is considered as the gold standard for BP in worldwide [1].

This approachis very intrusive, poses many dangers like bleeding and infection.It is only appropriate for significantly sick patients in hospitals, where it is predominantly utilizedthrough surgical operations and in intensive care units. Non-invasive cuff-based BP readings utilizing oscillometric methods are the gold standard in clinical practise. In contrast to BPmeasured invasively, cuff-based approaches enable BP readings without any notable negative effects. On the other hand, these devices employ an arm cuff that can only monitor BP sporadically with intervals of at least two minutes between readings. Wearing this equipment during measurements is very inconvenient [1].

Long-term monitoring can make patients uncomfortable because of the unpleasant cuff inflation, which disrupts normal blood flow. As a result, conventional clinical BP measuring methods are ineffective for continuous ambulatory BP monitoring. The PPG method allows for non-invasive BP estimate by viewing 2 waveforms derived from signals like2 PPG signals from 2 anatomical sites or a mixture of a PPG signal and an electrocardiogram (ECG). Earlier research has shown an inverse relationship among BP and pulse transit time (PTT). The PTT-based



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technique has been intensively investigated in recent years, with accumulating datawhich can offer non-invasive measures without the need of a cuff. The time it takes for the pressure waveform to travel among 2 artery sites is known as the PTT. Another prominent technique is pulse arrival time (PAT), which is described as the change in time among the R-peak of the ECG signal and the peak of the PPG signal when recorded inside the similar cardiac cycle. Pulse wave velocity (PWV) is another method for determining BP [2].Beyond fitness and heart rate monitoring, the PPG's principal medical use has been to gather information about the cardiovascular system in order to diagnose and treat cardiovascular disease (CVD). Heart failure, coronary artery disease, cardiomyopathy,arrhythmia, myocardial infarction, and peripheral artery disease are all examples of chronic disorders that affect the heart or blood arteries. Atherosclerosis (the build-up of fatty deposits within the arteries) and an improved risk of blood clots are common symptoms of CVD [2]. Figure 1 shows the Schematics of the LED and the receiver and demonstrates that the finger is placed between LED and Photodetector.

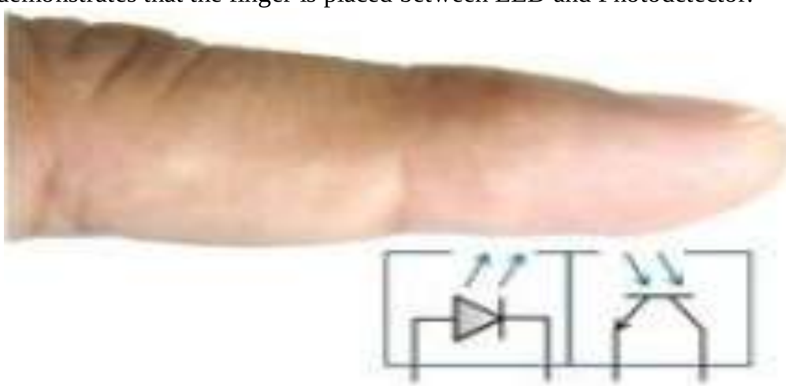

**Figure 1:-** LED and the receiver [3].

It is the leading cause of mortality worldwide, accounting for about 17 million fatalities. Cardiovascular disease is presently monitored or diagnosed utilizing a range of noninvasive methods, depending on the individual symptom. PPG, BP cuff, pulse oximeter,Holter monitor ECG, ECG through a stress test, magnetic resonance imaging (MRI), computed tomography (CT) scans and ultrasound imaging are some examples of devices[4].

## Literature Review:-

This section shows the several related work of many authors.

Kuncoroet al. (2020) [5]suggested a wireless PPG sensor that is small, inexpensive, power-efficient, and easy to use for real-time BP bio signal monitoring. BP signal shape detecting, data conversion, conditioning of signaland wireless transmission to a monitoring endpoint are all made easier with the suggested sensor. The data received may then be assembled and saved on a computer using a Wi-Fi module. Users can see BP signals being handled and presented on a graphical user interface (GUI) created utilizing a virtual instrumentation (VI) programme during monitoring. A finger clip optical pulse sensor, a microprocessor, analogue signal preprocessing, and a Wi-Fi module are all part of the suggested device. When functioning in active mode, it uses around 500mW of power and is made up of commercial off-the-shelf (COTS) components. The suggested gadget is dependable and allows for effective BP monitoring. The suggested wireless PPG sensor is a prototype (or early version) of the final product. It gives unclassified BP data for further analysis. Furthermore, the BP wave form data acquired can be simply analyzed for utilize in additional bio signal observations, interpretations, and studies. The gadget can also be integrated into a wearable system for additional study thanks to the design approach.

Gao et al.(2016) [6] suggested an automatically flexible integrated sensor array for multiplexed in situ perspiration analysis which detects sweat metabolites (like glucose and lactate), electrolytes (skin temperature concurrently and selectively. This suggested work combines plastic-based skin sensors with silicon integrated circuits consolidated on anelastic circuit board for complicated signal processing, bridging the technology gap among conditioning (filtering and amplification),wireless transmission, signal transduction, processing in wearable biosensors. Due to the intrinsic constraints of each of these technologies, this application could not have been implemented utilizing just one of them.

Zhang (2020) [7] suggested a novel multi-path reliable communication technique for marginal wireless sensor network (WSN) applications. This utilizes a redundancy mechanism to ensure data transmission reliability and simultaneous weaving multi-path equipment to boost data packet transmission efficiency. It separates the data packets that the sensor node must send into numerous sub-packets with data termination, and then passes the subpackets to the aggregation node by multi-path via the marginal environment's intermediate nodes. This suggested study demonstrate that the suggested multi-path reliable transmission approach can essentially minimize data packet loss rate, transmission latency, and network lifespan. The approach is highly beneficial for mediocre WSN applications.

Moraes et al. (2018) [8] suggested various techniques as well as the different kinds of sensors employed and the methods for studying and analyzing the PPG signal (linear and nonlinear approaches). Furthermore, the advancement of the PPG approach in the diagnosis of cardiovascular illnesses is assessed, as well as its clinical and practical usefulness. The newest technologies used in the creation of exclusive instruments for medical diagnostics, like as theInternet of Things (IoT), Internet of Health Technology (IoHT), genetic algorithms, (AI), and biosensors, are also discussed, resulting in individualized breakthroughs in e-health and health care. Following an examination of these machineries, this is clear that PPG, which is related with them, is an essentialdevice for the identification of certain diseases, owing to its ease, cost–benefit ratio, ease of signal attainment, and, most importantly, the fact that it is a non-invasive method.

Iozziaet al. (2016) [9]suggested Classic timeand frequencydomain variability indices generated from pulse rate variability (PRV) series recovered from video-PPG signals (vPPG) were matched to heart rate variability(HRV) parameters separated from ECG signals in this work. The research looks at the alterations that occur after a rest-to-stand manoeuvre (a modest sympathetic stimulation) on 60 young, healthy volunteers (age: $24pm 3$ years). The goal is to see whether video derived PRV indices can be used instead of HRV in assessing autonomic responses to external stimulus.

Li et al. (2015) [10] suggested a Support Vector Machine (SVM) related posterior probabilistic model (SVMPPM) for DDD with the goal of translating sleepiness levels to any value of 0 rather than distinct labels. A completely wearable electroencephalogram(EEG) system comprising of Bluetooth-enabled EEG headgear and a commercial wristwatch was utilized to test the suggested model in real time. This model was created with the help of twenty persons who shared in a one-hour driving simulation experiment, fifteen for the construction model and 5 for the testing model. The suggested system has an alert group accuracy of 91.25 percent, an early-warning group accuracy of 83.78 percent, and a full-warning group accuracy of 91.92 percent, corresponding to a video-based reference (91 out of 99 data sets). These data imply that the recommended EEG headband, SVMPPM, and wrist-worn smart device offer an efficient, easy, and cost-effective wearable treatment for driver drowsiness detection (DDD).

Temkoet al. (2017) [11]examines a new method WFPV which uses a Wiener filter to reduce motion artefacts, a phase vocoder to improve the Heart Rate (HR) estimate, and user-adaptive post-handling to follow the subject's physiology. In addition, for circumstances which don't need live HR monitoring (WFPV+VD), an offline variant of the HR estimate method which employs Viterbi decoding is devised. On a publicly accessible collection of 23 PPG recordings, the performance of the HR estimate methods is rigorously evaluated to current techniques. When compared to state-of-the-art PPG-based HR estimate techniques, the error rate is much lower. The suggested system is demonstrated to be accurate in the occurrence of significant motion artefacts, and it has relatively few free parameters to tweak, in comparison to current alternatives. The technique has a minimal processing cost and can be utilized in wearable devices for health monitoring and fitness tracking. The algorithm's MATrix LABoratory (MATLAB) implementation is available online.

**Problem Formulation**

High BPas a primary effect of mortality worldwide and a crucial factor in the development of severe disorders, involving cardiovascular diseases like heart failure and stroke.Recently, the significant intensity changes in modulation that can be noticed throughout the operation, yellow-wavelength PPG devices are becoming increasingly popular.Because yellow light provides the highest contrast, it has been shown to protect the retinas of people who have been exposed too much blue light. Yellow-lens sunglasses may be particularly efficient at filtering out not just UV but also blue light.An advantage of using yellow LED lights is that it usually have a dimmable feature, which further customizes their uses. As compared to red/ green LED, Yellow light has much greater absorptivity for both oxyhemoglobin and deoxyhemoglobin and alsofollow a better signal-to-noise ratio (SNR).The green light persistently produced by the LEDin the wearable items which is likewise absorbed by the body, drastically limiting the depth to which light can flow through it. This causes substantial issues at the wrist, where blood flow is restricted, lowering the signal's overall intensity. Skin tone is another complication for green light sensors. Melanin, a natural pigment present in almost all organisms is responsible for skin colour.

**Important Parameters and techniques used in proposed Methodology**

Following are the important parameters and techniques that are used in proposed methodology:

**PPG**

PPG sensors are frequentlyutilized to identify pulse transit time (PTT) for possible cuff-less BP monitoring. The contact pressure (CP) of the PPG sensor is known to change the amplitude of the PPG waveform.PPG comes from the Greek word plethysmos, meaning improvement. It is defined as identifying differences in the size of a physical portion because of variations in the volume of blood flow. Traditional plethysmographs like strain gauges, are able of sensing changes under harsh circumstances and may be used to measure pulsatile tissue volumes. This method can be used to determine the total volume change of any blood artery.

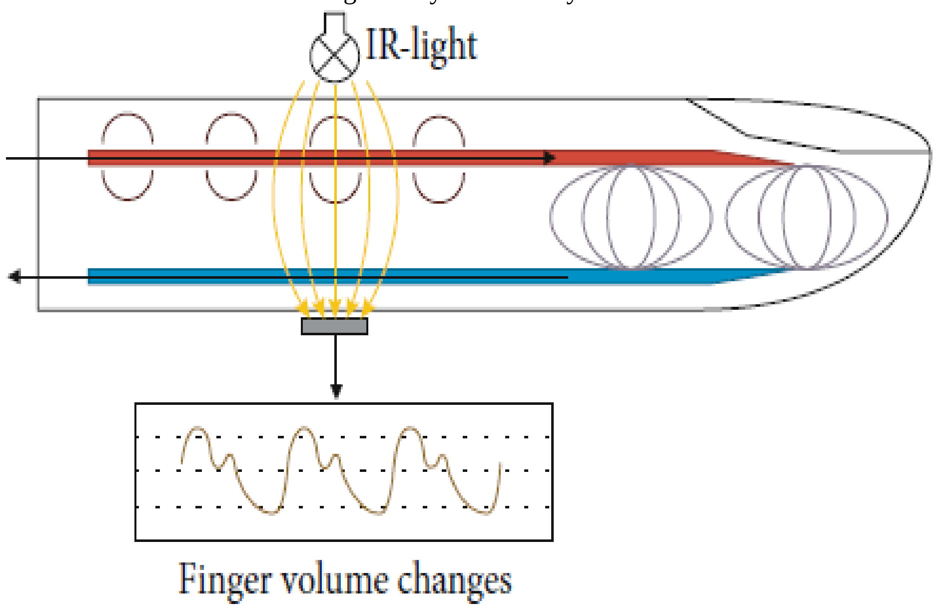


**Figure 2:-** Principle of PPG [5].

The most important pulsations are those in the arteries, but capillaries are extremely uncooperative since they only register tiny pulsations. Venous oscillations can occur depending on the measuring method; however, they are often stopped when external pressure is applied. A plethysmogram can be used to assess arterial blood pressure indirectly.PPG devices can't monitor BPwhile in transmission mode, but it can assess changes in blood volume. Figure 2 depicts the PPG principle [5].

**Band Pass Filter (BPF)**

BPF is a circuit which accept signals in a certain frequency range to pass while attenuating signals outside of that range. BPF are divided into 2 categories: narrow and wideBPF. Regrettably, there is no clear distinction among the 2. A BPF is classified as a widebandif its figure of merit or quality factor (Q) is less than 10, while narrow BPF have Q > 10. As a result, Q is a selectivity metric with greater value.

**Pre-processing**

Data preprocessing is the method of transferringunprocessed data into a format which can be identified easily. Data in the real world is often partial, inconsistent, redundant, and loud. Data preprocessing includes a number of stages that help in the transfer of unprocessed data into a functional format [5]. Figure 3 depicts the whole pre-processing procedure.

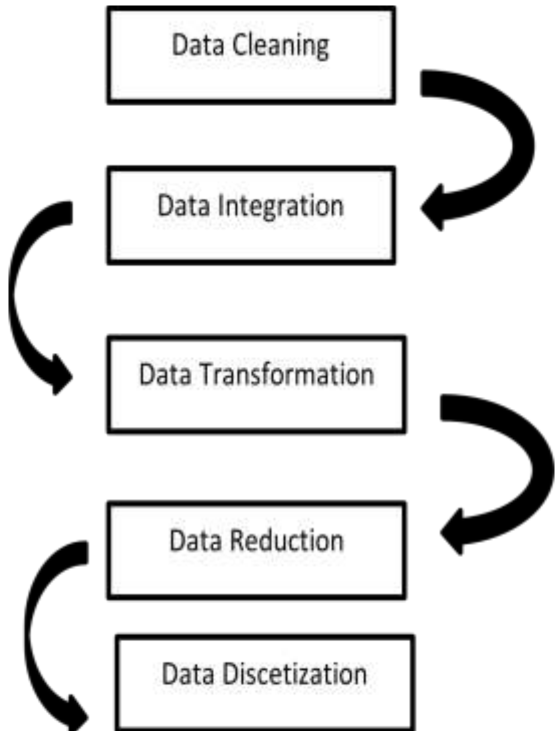


**Figure 3:-** Data Preprocessing Steps [5].

Following are the steps of Data processing [5]:

**Data Cleaning**
The practice of discovering defective data and erroneous entries from a record set or database table is known as data cleaning. The major purpose of the cleaning process is to identify incomplete, incorrect, inconsistent, and irrelevant data and then utilize strategies to alter or eliminate it.

**Data Integration**
Data integration is concerned with the unification of data from several sources and the presentation of a unified perspective of that data. Data with various representations is combined, and any conflicts that arise are handled.

**Data Transformation**
When it comes to transforming raw data into intelligible form, data transformation is critical. Data standardization, aggregation, and generalization all are part of Data Transformation.

Data transformation plays a pivotal role in converting unprocessed data into understandable form. It consists of data normalization, aggregation and generalization.

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**Data Reduction**
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The process of converting digital data into an organized and easier format is known as data reduction. This information is usually gathered utilizing experimental and empirical methods.

**Data Discretization**
A big quantity of numeric data to categorize andrelated nominal values are known as Data Discretization [4].

Data discretization is an important concept when you have a large amount of numeric data, but only want to classify it based on nominal values.

Data reduction is the process of transforming digital info into ordered and simplified form. This data is generally derived through empirical and experimental means.

**Cross Correlation**
It is a measure of self-similarityamong 2 waveforms f(t) and g(t), $\emptyset_{fg}(\tau)$ represent the cross correlation[12]:

$$\emptyset_{fg}(\tau) = lim_{T\to\infty}\frac{1}{T}\int_{-T/2}^{T/2} f(t)g(t+\tau)d\tau \quad (1)$$

in the case of infinite duration waveforms, and for finite duration waveforms.

$$\rho_{fg}(\tau) = \int_{-\infty}^{\infty} f(t)g(t+\tau)d\tau \quad (2)$$

Where $\rho_{fg}(\tau)$ is Root mean variance, f (t) and g(t) wave are waveforms.

**Time Delay**
 ose delays can cause insta-
bilities of original systems and make it harder for the system analysis, controller design or state estimation. To tackle these disadvantages, special attention must be paid and necessary compensationshouldbeappliedinthedesignprocess.Onthe other hand, the nice properties of time delays may also bring a new vision for our practical design. For example, if dealt with properly, the delay elements can really be treated as the oscillation generator or chatting compensator

In the field of engineering, time delay is a relatively typical occurrence. Many industrial processes in fact, involve after-effect events as part of their internal dynamics. In addition, feedback loop actuators, sensors, and field networks almost always include inevitable delays. Time delays are a part of many engineering systems and itfrequently degrade the primary system's performance.

Delays can induce instabilities in original systems, controller design, making system analysis, and state estimation more difficult. Special attention and adequate compensation should be made to these flaws throughout the design phase to combat them. The enticing aspects of time delays might give a new viewpoint for practical design. If correctly handled the delay elements for example, it can be used as an oscillation generator or chatter compensator [6].

## Research Methodology:-
This section represent the proposed methodology. As green lightis more expensive than theyellow, because green light contains the externalized environmental costs of many traditional manufacturing processes and the other most disadvantage of green light sensors is skin tone.Darker skin engages more green light and generating an obvious troublefor signal. Selective yellow light is used to increase visibility. Yellow light revitalizes the skin, increases wound healing, improves blood circulation to the skin's tissues, and reduces signs of ageing like fine lines and wrinkles. Yellow color reduce the heat compared to the warm colors; it create a mentality of overheating the space

compared to the colors. That's why in the proposed methodology, Yellow Light is used in place of Green Light. To propose this methodology some steps followed as:

**Step 1 (PPG signal or Yellow Light)**
Yellow light isused as an input in this methodology because the PPG devices utilize an LED operating on one side of the tissue and a Photo detector on the other to determine the absorption and obstruction of incident light. Ifphotodetector and LED both are positionedclose to each other, every incident light can imply off the tissue surface.

**Step 2 (Band pass filter)**
For the analysis of this signal, it is required to getusage of amplification and filtering circuits. BPF removesunnecessary signal,also decreasing noise interference above 60 Hz and allow signals within a selected range of frequencies.

**Step 3 (Pre-processing)**
Pre-processing makes the raw data into an understandable format. It is also an important step in this methodology.

**Step 4 (Cross correlation)**
Cross correlation tracks the movements of two or more sets of time series data relative to each other.

**Step 5 (Time Delay)**
In this step, the time delay is used for controlling the data or signal based on time.

**Step 6 (Display)**
In the last step, the received outcome can be shown on digital display or smart watch.Figure 4 shows the proposed methodology in pictorial representation.

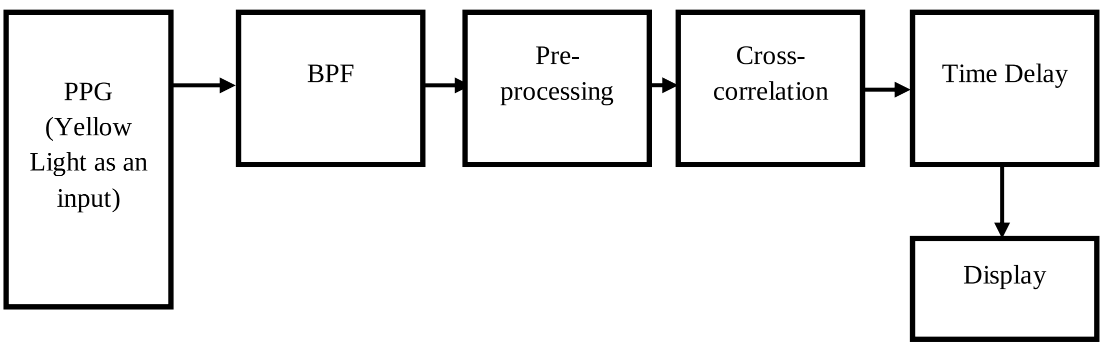


**Figure 4:-** Proposed methodology in a pictorial representation.

A Yellow led light developed PPG signals which are initiallyproviding as input to a BPF by a signal conditioning circuit.The output of the Band pass filter work as an input for preprocessing step. Pre-processing transforming raw data into understandable format and remove all the redundancy from the signal. The received data are now passes with the cross-correlation step that tracks movement and variation among two signals. Time delay is utilized for obstructing the start-up, recycling, shutdown, or continuation of processing operations. until the desirable requirements have been fulfilled or the necessary conditions have been achieved. Now in the final step, the received outcome can be shown on digital display.

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