# Evaluating Impact of Temperature Stimulus on Signal Quality from a Wearable Pulse Optical Sensor

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***Abstract-***

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## 1 Introduction

Cardiovascular diseases (CVDs) are the leading cause of death in the world, hitting over 17 million people, which was 31% of all global deaths in 2016. In Brazil, there are 300 thousand cases of CVD deaths per year (Portal Brasil, 2017). This brings out our attention the need for new methods that can reduce these numbers in the near future. Factors as obesity, tobacco and alcohol use, and a sedentary lifestyle can increase the risk of CVDs (World Health Organization, 2017). People with these habits need to change their lifestyle and have a doctor appointment for early detection of heart diseases.

On the other hand, there are several ways of detecting abnormalities in the heart. There is one screening tool that is being used to track heart activity, which was the heart rate variability (HRV). The HRV can be combined with blood pressure (BP) to detect abnormalities in the heart (RAJENDRA et al., 2014, Chapter: Heart Rate Variability). There are some exams that can be used for heart monitoring, such as Electrocardiogram (EKG), cardiac magnetic resonance imaging (MRI), Holter monitoring, ambulatory blood pressure monitoring, pulse oximetry, etc. These exams can be used to detect heart disorders in many stages, where some of them can be used inside or outside the doctor's office.

The pulse oximetry is a particular exam that is used for HRV visualization. The pulse oximeter was created in 1972 by Takuo Aoyagi (AOYAGI, 2005) and it is a device that changed the course of medicine in aspects of blood oxygen level, especially in the operating room. This device performs the measurement of blood oxygen saturation levels in a non-invasive way, besides of measuring the pulse rate of the patient, in beats per minute (World Health Organization, 2011), by using the emission of light directly on the skin surface. Usually, this device is found in many operating rooms and intensive care units in hospitals around the world. The concept of pulse oximetry is going to be explored in detail in the next chapter.

In the first chapter, it can be found the basic fundamentals around the technologies applied for this work. In the second chapter, it is shown all the steps for prototyping and developing the new device. The third chapter shows all the steps of the experiment performed in users, while in the fourth chapter it is discussed all the results obtained. Finally, in the fifth chapter, there is the conclusion and suggestion for future works.

# 2 Theoretical Basis

## 2.1 Pulse Oximeter

The pulse oximeter measures the oxygen level in the blood by emitting light directly to the patient's skin. This light is either red, green or infrared, which is read by a photodiode. The sensor can be placed in the fingertip, toes or the earlobe. These regions have a large number of blood vessels and have the ideal width for the measurements. The hemoglobin in the blood absorbs the lights emitted by the device, and the signal received in the photodiode varies according to the hemoglobin oxygen absorption.

To measure the heartbeat, the pulse oximeter is directly related to the heart's plumping performed by the heart, but still uses the light emission and reading by the oximeter. When the heart performs the systolic movement, which is the heart's contraction, the blood spreads through the body and where the pulse oximeter is placed has a larger amount of circulating blood on it. This causes an increase in the signal level because there is more hemoglobin in the blood. In the diastolic movement, the heart is expanded and consequently, there is a smaller amount of blood circulating where the pulse oximeter is located, reducing the level of the signal.

## 2.2 The Blood Circulation

The Heart Rate (HR) is the speed of the heartbeat, measured in beats per minute. The HR can be affected by the body temperature (HALL; GUYTON, 2006). When the temperature is high, as when a person has a fever or practicing sports, the heart increases its permeability, causing the heart muscles to accelerate. The opposite happens when the body is in a lower temperature like in a hypothermia, the heart decreases its permeability and consequently reduces the heart rate.

This behavior of the heart also applies to the body vessels. The effect can happen in the whole body and even in small areas. There are factors that can cause more or less blood flowing in the vessels, which causes the effect of vasodilation or vasoconstriction, respectively. These factors can be thermal changes, exercises, substances in the circulatory system, etc.

For the proposed work, we chose to use thermal changes in the skin temperature in order to get vasoconstriction and vasodilation. Local thermal changes are the easiest way, non-invasive and without moisture to provoke the desired effect.

## 3 Materials and Methods

### 3.1 Location and Ethical Approval

### 3.2 The Prototype

### 3.3 Experiment Design

## 4 Results and Discussion

## 5 Conclusion

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