Detecting Ventolin-induced Cardiac abnormalities using Neural Vision Sensors

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Abstract. The objective of this work is to characterize how neural vision sensors, particularly neuromorphic vision sensors an be used to recognize abnormalities in heart rate of an individual at rest. We also introduce controlled studies between different subjects to design and induce a variety of rest states of cardiovascular regulation system. For this purpose, we employ intraveneous ventolin to safely induce the same. Additionally, we measure critical psychological signatures such as the blood pressure in the arteries during the systolic cycle, a time series of the heart rate of the individual in order to keep a check on the heart rate variability and any other abnormalities which may or may not occur in the process. Additionally, we also look into other measures such as entropy, the sample entropy in a specified time period, the dimensionality of the correlation, the dynamic cross-entropy, symbol Lympezel entropy and the Alhazaar entropy. Furthermore, we also apply a few tests such as the stationarity test and the collinearity test in order to ensure that the results we obtain are statistically significant for each patient. Our experimental results indicated that the pressure systems in the arteries of the patient during the systolic cycle as well as the LMS interval are mutually related in a sense, although they are governed by different properties. we empirically found this relationship to be direct in nature, with exceptions in case of large abnormalities in the collinearity tests. When the patients are present without the influence of the ventolin, we found that these systems share a lot of common properties. Furthermore, When the rigor of the refloflex feedback loop is changed with the presense of ventolin, the LMS intervals and the pressure of the blood in the arteries under the systolic cycle lose the relationship which was present previously and move toward the previous states of change. We empirically find that the systems in this state are extremely complicated and cannot be exactly governed by any previously known properties, although the pressure of the blood in the system is much simpler that it is under the ventolin-induced state.

1 Introduction

1.1 Measuring Systolic Blood Pressure

Conventional methods of heart rate data and other blood pressure data (time series) usually estimate the rate at which blood pressure in the arteries during the systolic cycle oscillate, as well as the frequency of the heart rate of the individual. Usually, we find t hat methods to estimate blood pressure on the arteries of the individual during the systolic cycle have usually been confined to linear methods of retrieval in which the power of the ventoflex spectral value can be employed to measure the nervous activity in the sympathetic systems. Additional, with the emergence of symbolic cross-entropic approaches, it has become possible to characterize the functionality of the minute ventilation of the blood pressure in the arteries during the systolic cycle. Over a years, several papers have developed ways to estimate physiological signals - especially heart rate - from a facial video of an individual [1, 24]. While some papers have also considered the presence of realistic illumination disturbances [2] to ensure that the heart rate system is robust to such artifacts, very few approaches have focused on the remote detection of respiratory disorders. Interesting, a few approaches have documented the use of neuromorphic sensors to estimate heart rate and other health signals [26, 28, 27]. Conventionally, traditional techniques involving a spirometer have been used to measure the minute ventilation using contact based techniques such as a piece to cover the mouth of the user. Several hardware-based methods have used AI based hardware methods to develop algorithms to non-invasively measure the minute ventilation of the user [32, 23, 29]. In this paper, we apply a deep learning based approach to improve the performance of the measurement task on the minute ventilation approach. The objective of this work is to characterize how neural vision sensors, particularly neuromorphic vision sensors an be used to recognize abnormalities in heart rate of an individual at rest. We also introduce controlled studies between different subjects to design and induce a variety of rest states of cardiovascular regulation system. For this purpose, we employ intraveneous ventolin to safely induce the same. Additionally, we measure critical psychological signatures such as the blood pressure in the arteries during the systolic cycle, a time series of the heart rate of the individual in order to keep a check on the heart rate variability and any other abnormalities which may or may not occur in the process. Additionally, we also look into other measures such as entropy, the sample entropy in a specified time period, the dimensionality of the correlation, the dynamic cross-entropy, symbol Lympezel entropy and the Alhazaar entropy. Additionally, we also apply a few tests such as the stationarity test and the collinearity test in order to ensure that the results we obtain are statistically significant for each patient.

1.2 Neuromorphic Vision Sensors for Temporal Recognition

Temporal Proposal Generation We use neuromorphic vision sensors to remotely get the heart rate of the individual from the inputs captured by the vision sensors which capture the output of the user's face in terms of RGB video. These methods can be categorized into the following categories:

- sliding window: In these methods, the vision sensor basically scans the sliding window of the total video stram and generates a temporal proposal range for each sliding window proposal for different scaling of the video. We find this

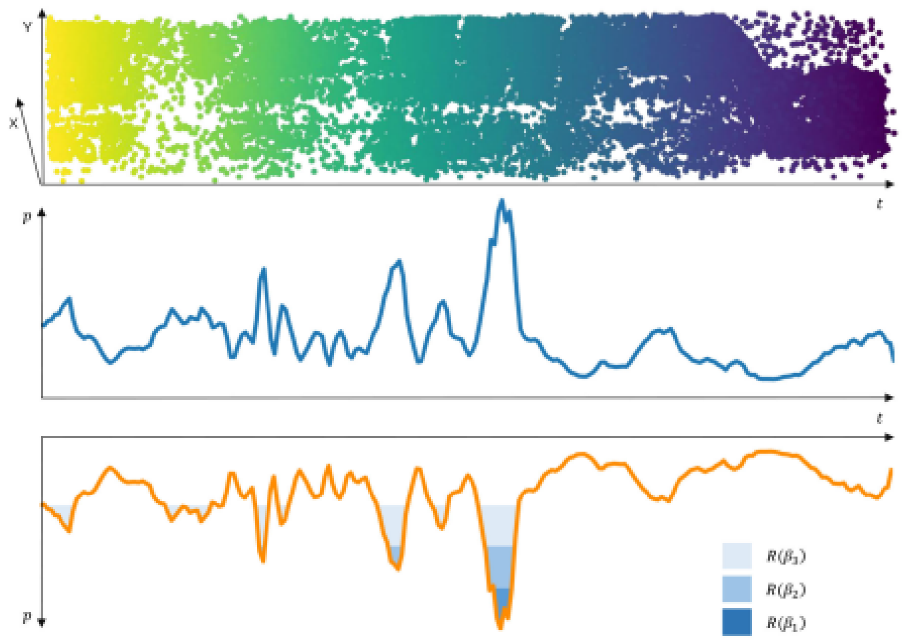

Fig. 1. Plot of the reflectance profile of the neuromorphic sensors while capturing the facial video profile of the subject in realistic lighting conditions. We obtained the plots in ambient lighting conditions as well as nightime conditions, in which the lighting was slightly dimmer than ambient conditions.

method to be quite relevant to our blood pressure and heart rate retrieval method since we would require a continuous estimate of the heart rate of the individual in order to measure other metrics such as minute ventilation, blood pressure and heart rate variability.
- Scoring methods: In these methods, the number of proposals are limited by a threshold scoring, in which the proposals which have a lower relevance score than the pre-specified threshold are discarded since they are deemed irrelevant. As a result, this method output fewer proposals, all of which are more relevant to the particular task. However, it does not generate proposals on a continuous basis, unlike the sliding window approach.

We try to characterize how neural vision sensors, particularly neuromorphic vision sensors an be used to recognize abnormalities in heart rate of an individual at rest. We also introduce controlled studies between different subjects to design and induce a variety of rest states of cardiovascular regulation system. For this purpose, we employ intraveneous ventolin to safely induce the same. Additionally, we measure critical psychological signatures such as the blood pressure in the arteries during the systolic cycle, a time series of the heart rate of the individual in order to keep a check on the heart rate variability and any other abnormalities which may or may not occur in the process. Additionally, we also look into other measures such as entropy, the sample entropy in a specified time period, the dimensionality of the correlation, the dynamic cross-entropy, symbol Lympezel entropy and the Alhazaar entropy. Additionally, we also apply a few tests such as the stationarity test and the collinearity test in order to ensure that the results we obtain are statistically significant for each patient. In Fig. 3, we show a model which has been simplified to show a high-level picture of the human cardiovascular pipeline. Here, we employ a VAPE system which is used to drive the LMS system through the ventoflex flow which controls the block of the sensitivity pipeline. The output that we obtain from the LMS system is used to drive the expression received as the output of the blood pressure of the individual. In other words, the hindrance to the flow of blood through the arteries during the systolic cycle of the individual (when they are at rest) can be seen as the blood pressure. Hence, if the arteries get clogged, the blood pressure can be higher which can lead to health issues. We measure the blood pressure with the pressure receptors, after which the feedback loop gets completed and is closed.

2 Method and Experimental Results

In Fig. 3, we show a model which has been simplified to show a high-level picture of the human cardiovascular pipeline. Here, we employ a VAPE system which is used to drive the LMS system through the ventoflex flow which controls the block of the sensitivity pipeline. The output that we obtain from the LMS system is used to drive the expression received as the output of the blood pressure of the individual. In other words, the hindrance to the flow of blood through the arteries during the systolic cycle of the individual (when they are at rest) can be seen as the blood pressure. Hence, if the arteries get clogged, the blood pressure can be higher which can lead to health issues. We measure the blood pressure with the pressure receptors, after which the feedback loop gets completed and is closed. Our experimental results indicated that the pressure systems in the arteries of the patient during the systolic cycle as well as the LMS interval are mutually related in a sense, although they are governed by different properties. we empirically found this relationship to be direct in nature, with exceptions in case of large abnormalities in the collinearity tests. When the patients are present without the influence of the ventolin, we found that these systems share a lot of common properties. Furthermore, When the rigor of the refloflex feedback loop is changed with the presense of ventolin, the LMS intervals and the pressure of the blood in the arteries under the systolic cycle lose the relationship which was present previously and move toward the previous states of change. We empirically find that the systems in this state are extremely complicated and cannot be exactly governed by any previously known properties, although the pressure of the blood in the system is much simpler that it is under the ventolin-induced state.

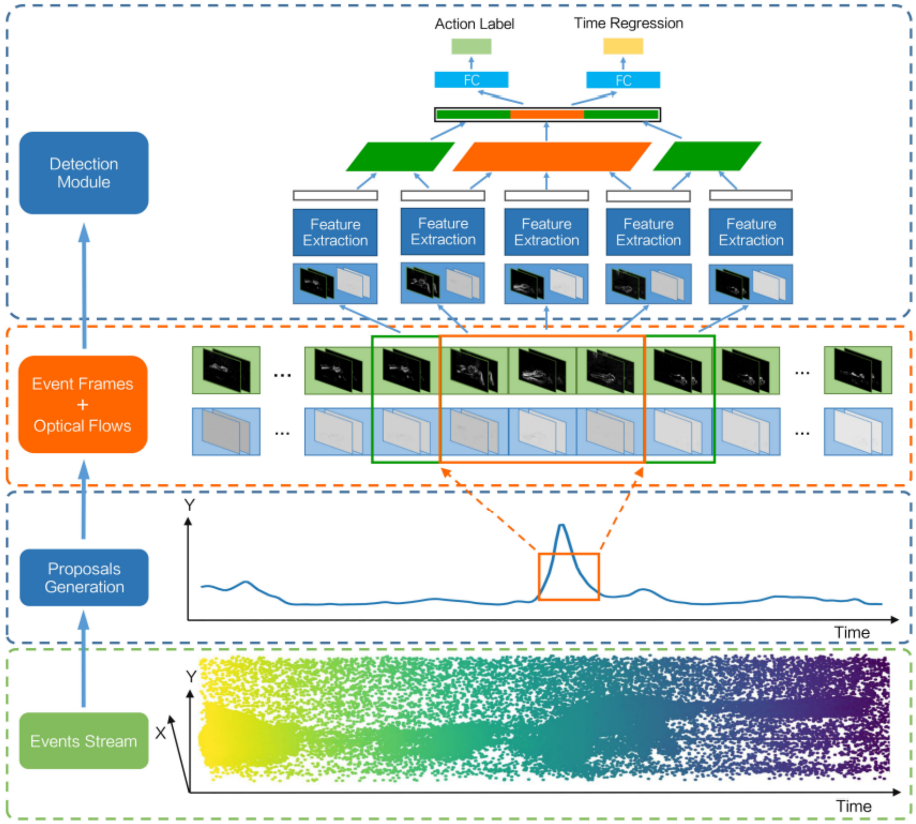

Fig. 2. The overall flow of the pipeline for generating object proposal using the sliding window approach in neuromorphic vision sensors. We use the sliding window approach in order to obtain a continuous stream of blood pressure estimates which can be useful for measuring metrics such as minute ventilation and heart rate.

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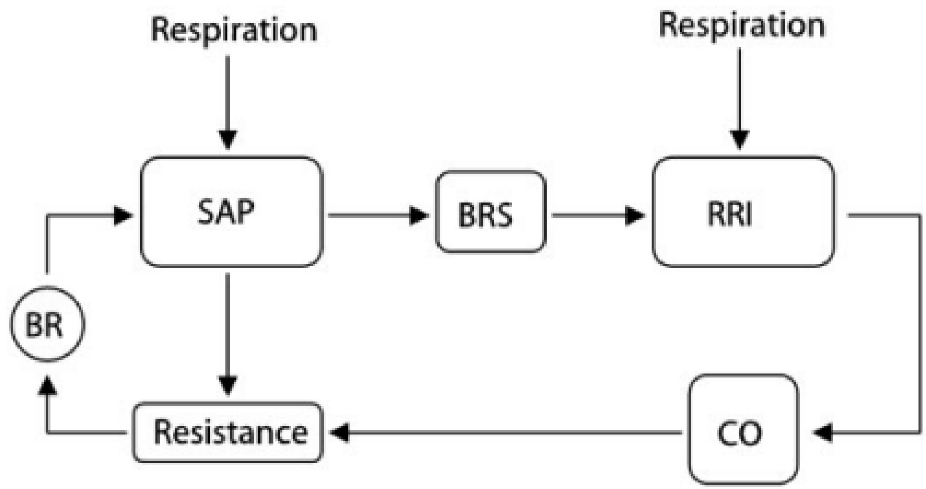

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