Heart Rate Variability Measurement Using Data Acquisition (DAQ) Device

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ABSTRACT: Heart Rate Variability (HRV) has increasingly been used outside of clinical application in recent decades. As the number of applications grows, the development of method to detect heart rate variability is also expanding. This paper discusses a preliminary result of HRV measurement using Data Acquisition (DAQ) device. The proposed system uses National Instrument (NI) CompactDAQ-9174 device with NI 9215 series as an analog input module. The proposed system is expected to exhibit higher level of reliability, robustness, and I/O versatility.

Keywords: *Heart Rate Variability (HRV); Data Acquisition (DAQ); Electrocardiogram (ECG)*

1. HRV BACKGROUND

Heart Rate Variability; (HRV) are used as clinical and investigative tools for various applications such as disease analysis, identifying stress level, and early recognition indicator for autonomic nervous system dysfunction [1]. Heart rate variability is a measure of the beat to beat variation or the time interval between consecutive heartbeats in milliseconds as shown in Figure 1.

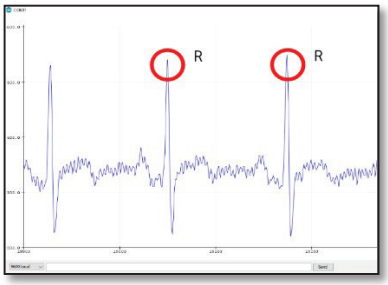

Figure 1 R-to-R interval of normal human

The most famous HRV application is for stress level monitoring systems. Stress can be detected by examining biological effects on human bodies, which are proven by researchers [2]. The stress level changes as the variability in the heart rate changes. Calculating the time interval between one heartbeat peak and the next heartbeat peak will measure the heartbeat variability. The heartbeat peak usually measured in the medical term with an electrocardiogram (ECG) from the QRS complex and taken from an ECG signal. Besides using HRV to monitor stress or mental illness, there are also studies that use HRV measurement to monitor hypertensive patients. The HRV's sensitivity to various medical conditions reflects its increased use by doctors as a diagnostic, prognostic, and efficient treatment tool. Borderline hypertensive patients with or without a cardiac history are frequently at high risk of stroke and heart death. Monitoring HRV parameters for such high-risk cases will be helpful when necessary, for the provision of adequate medical care. The study proposes using wireless Zigbee with an Internet of Things (IoT) to monitor hypertension patients [3].

2. PROPOSED SETUP FOR HRV MEASUREMENT

It is established that Arduino is one of the embedded microcontrollers and the most common hardware that is used to get HRV measurement. The proposed system used a National Instrument (NI) CompactDAQ-9174 device with NI 9215 series as an analog input module. This due to the NI CompactDAQ platform is a rugged and dependable embedded system from NI that offers deterministic LabVIEW Real-Time applications a powerful independent or networking execution capability. This system has a high level of reliability, robustness, and I/O versatility [4]. And its versatile communication interface can cater to the needs of a wide range of devices. The system starts with getting a measurement of ECG signal using an AD8232 sensor connected to the NI 9215 analog input module, as shown in Figure 2, where the output AD8232 is connected to NI 9215 AI0+ with the AI0- has been grounded. The AD8232 1 x 3 male header containing electrodes is placed on the skin at the right and left side of the chest, with the last electrode is placed at the lower right of the abdomen.

Next, the output signal is acquired using an NI 9215 device that later the data are sent to the computer using a USB hub from NI cDAQ 9174. Then the raw data is converted into a digital signal using ADC before it can be analysed and monitor using LABVIEW software. In the LABVIEW, a peak detector is used to detect the R-R time interval of the ECG signal in milliseconds, and the founded peak between 5 seconds is used to display beats per minute (BPM) by using the following Equation (1).

$$\text{BPM} = \text{Number of peak found in 5s} \times 12 \quad (1)$$

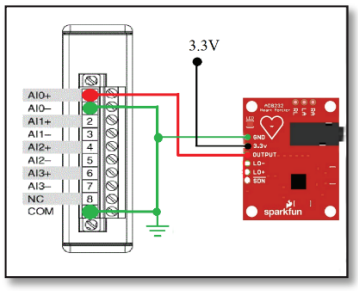

Figure 2 AD8232 sensor connection to NI 9215

3. TESTING AND PRELIMINARY RESULTS

A healthy 22-year-old adult has been tested for the proposed setup, and the results of normal resting heart rate are around 85 to 90 beats per minute with the mean of R-R time interval 700 to 800 milliseconds, as shown in Figure 3. The preliminary results indicate a reliable HRV reading and accuracy. Based on the preliminary results, our HRV measurement are getting in range of theoretical when we compared the HR reading using a Garmin Fenix 5X Plus Watch. As shown in the results, the value measured by our proposed setup as Garmin Fenix 5X Plus Watch difference ranged from 2-4 beats per minutes only, as shown in Figure 3 and Figure 4. In conclusion, we assume our proposed setup has higher accuracy than Garmin Fenix 5X Plus Watch since our proposed setup is applying the ECG method for HRV measurement.

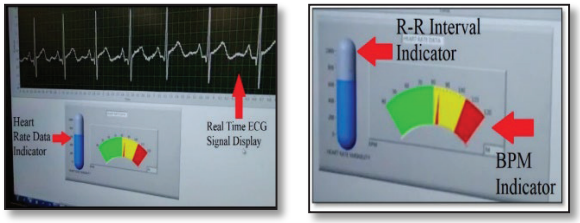

Figure 3 Results shown in LABVIEW

Figure 4 Results Comparison with Garmin Fenix 5X Plus Watch

Figure 5 Noise Occur Due to Wrong Connection

The first test result is not as expected, which is shown in Figure 3 due to the ECG signal acquired is too noisy, which is shown in Figure 5. This is due to the NI9215 terminal A0+ and A0- has a maximum range of +/- 10V from its own ground reference (COM), and the battery used as a voltage source where it is a floating (unreferenced) voltage source. It creates a differential signal that floats out of the range of the DAQ with will creates noise to the input signal. After some fact finding, it is found that the solution is to bridge the AI- and COM (common ground) terminals to the ground of the voltage sources, such as the connection shown in Figure 2.

4. CONCLUSION

The use of Data Acquisition (DAQ) device to measure heart rate variability has proven to be beneficial. Since the setup was built with low-cost material, this application can potentially be developed for wider application especially for wearable device. Even though this setup is working, further experiment is needed to capture HRV measurement in actual condition based on the preliminary results and other more investigation about the difference in using ECG and PPG to show with is more accurate and to used HRV result to determine the stress level of patients.

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REFERENCES

[1] K.Trimmel, J. Sacha, and H. V Huikuri, *Heart Rate Variability; Clinical Applications and Interaction between HRV and Heart Rate:* 2015

[2] A. P. Allen, P. J. Kennedy, J. F. Cryan, T. G. Dinan, and G. Clarke, "Biological and psychological markers of stress in humans: focus on the Trier Social Stress Test.," *Neurosci. Biobehav. Rev.*, vol. 38, pp. 94–124, Jan. 2014, doi: 10.1016/j.neubiorev.2013.11.005.

[3] R. N. Kirtana and Y. V. Lokeswari, "An IoT based remote HRV monitoring system for hypertensive patients,"*Int. Conf. Comput. Commun. Signal Process. Spec. Focus IoT, ICCCSP 2017*, 2017, doi:

10.1109/ICCCSP.2017.7944086..

[4] J. Ye, H. Hu, Z. Wang, and R. Sheng, "Design of Model Elevator Control System Based on NI CompactRIO and LabVIEW," *Proc. - 2016 9th Int. Symp. Comput. Intell. Des. Isc. 2016*, vol. 1, pp. 68–73, 2016, doi: 10.1109/ISCID.2016.1024.