RASPBERRY PI AS A FRAMEWORK FOR A PAIN SIGNALING SYSTEM IN THE NEONATE

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Abstract

In the Neonatal Intensive Care Unit (NICU) patient monitoring is continuous and the most frequent parameters followed are the heart rate (HR) and peripheral oxygen tissue saturation (SpO2). These parameters are also used in neonatal pain assessment when applying various pain scales. Thus, using the Rapsberry Pi, a tool of Internet of Things (IoT), we created a script of data collection during NICU patient monitoring by pulse oximetry and we proposed a framework for a pain signaling system in the newborn. Data was collected by monitoring neonates undergoing painful procedures (heel stick for hypothyroidism and phenylketonuria screening and during Bacillus Calmette–Guérin (BCG) vaccination. Data plotting using the Jupyter Notebook revealed similarities in between the increase of heart rate in the presence of the painful stimulus that may lead to creating a pain signaling system in the neonate using artificial intelligence tools.

Keywords: pain, procedural pain, neonate, Internet of Things, Raspberry Pi

Introduction

Pain is considered to be the fifth vital sign that needs to be recognized and monitored in any medical ward (1). According to several studies the neonate experiences pain just like any other older child or person, however due to their impossibility to state their discomfort or degree of pain, assessment and signaling pain in the newborn is difficult (2).

Over time multiple validated pain scoring systems have been created, but there is no standardized means of assessing neonatal pain (3), and during their stay in the NICU the newborns are subjected to a multitude of painful procedures needed for both diagnosis and treatment (4-6).

What is more, the lack of diagnosis and medical intervention to neonatal pain results in physiological and behavioral impairments, together with injury to the nervous system that lead to an altered development of the future person (7).

On the other hand, impressive technological advancements have been made in most medical fields. Neonatology registered a real "boom" in this regard over the past few decades. However great costs are involved when acquiring new technology.

The Internet of Things (IoT) defined as a interconnection among people, animal or object that is often equipped with intelligence able to exchange data over a network without involving human beings or other devices (8). And, it should allow new applications to be added, thus promoting innovation and cross-domain systems and applications to be developed (9, 10).

Within the IoT, a special object is the Raspberry Pi (RPi) a low cost, small and portable computer board that can be used as a standard PC, with a keyboard for command entry, a display unit and a power supply (11). It has a built in software that permits program or script developing and design of animation, game or videos (8).

Thus the aim of this paper is to propose a framework for a system that signals pain in the neonate using a data acquisition script created with Python and runs on a RPi.

Material and method

The project was conducted in between September - November 2017 in the Neonatology Department of the Bega University Clinic from the Timisoara County Emergency Clinical Hospital.

For this project we used: Rapsberry Pi 3 B Model, Massimo Radical 7 pulse oximeter, FTDI RS232-USB convertor, network cable and a notebook. We developed a script for data collection using Python v. 2.7 that records HR and SpO2 values of the patient during pulse oximetry monitoring. We performed data collection on 10 patients during procedural induced pain in the healthy newborn, undergoing standard heel stick procedure for hypothyroidism and phenylketonuria screening and during Bacillus Calmette–Guérin (BCG) vaccination. Data was analyzed using Jupyter Notebook.

Results

Using Jupyter Notebook, an open-source software that interactively allows use of code execution, rich text, mathematics, graphical representation and a variety of materials, we found a series of similarities in the charts created, based upon data collection from newborns undergoing procedural pain.

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Below is the data plotting with two data parameters: HR and SpO2. In Figure 1, is data collected from five neonates during heel prick test and the arrow indicates the moment of procedural pain induction. Figure 2 contains the representation of data collected during BCG vaccination in neonates. The first arrow in each picture represents the moment of pricking whereas the second arrow represents the moment of substance injection.

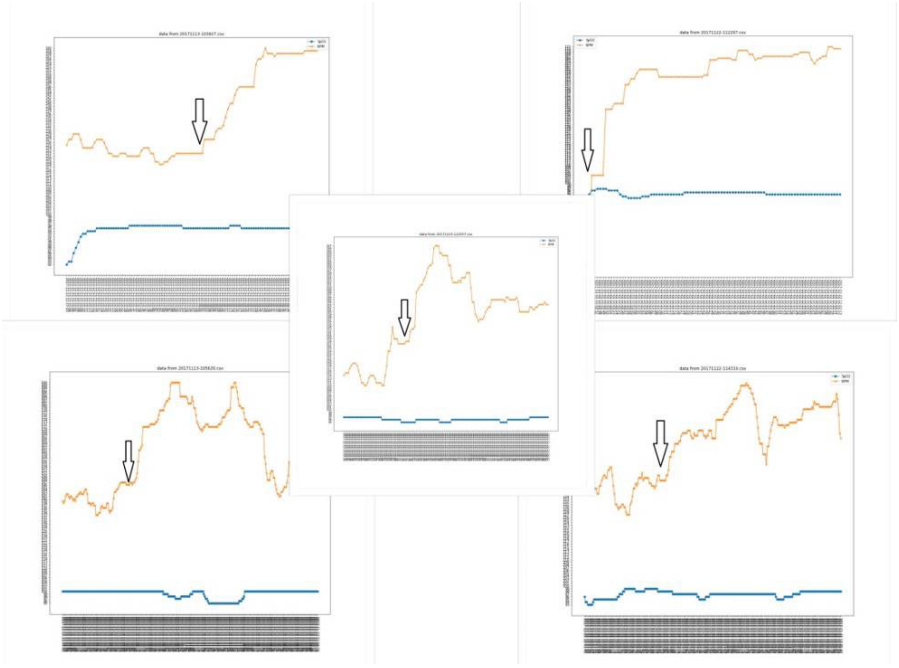

Figure 1. Heel prick test in five neonates.

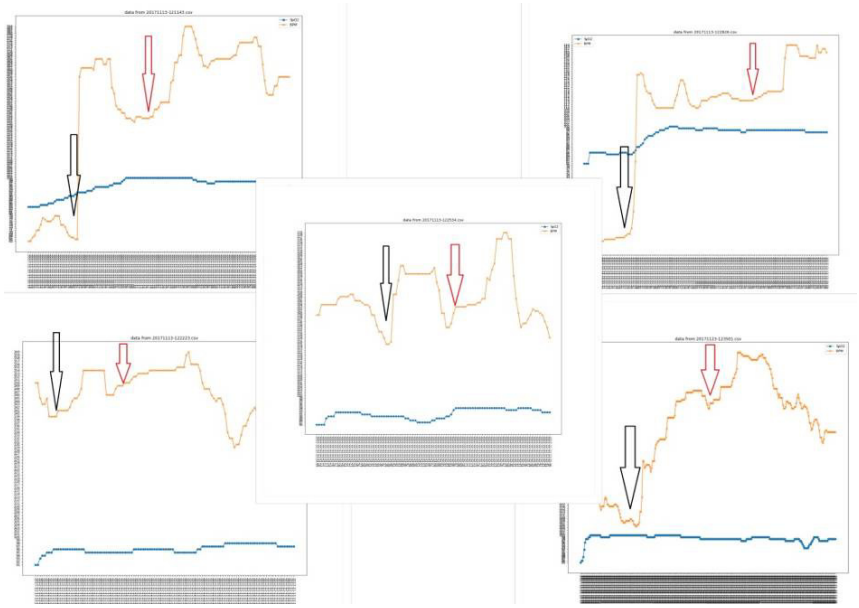

Figure 2. BCG vaccination in five neonates.

Discussions

Impressive pieces of evidence show that the newborn detects, perceives and responds to painful stimuli. They respond by three means that are: behavioral (facial expression, crying, motor response); physiologic and autonomic (HR, respiratory rate, blood pressure, intracranial pressure, sweating, decrease in SpO2, skin color, nausea, vomiting, hiccoughing, etc.) and biochemical (increased secretion of catecholamines, epinephrine, glucagon, corticosteroids/cortisol and decreased secretion of prolactin, insulin and immune responses) (1).

What is more, several pain scales are used to evaluate pain in the neonate: the neonatal infant pain scale (NIPS); neonatal facial coding system (NFCS); neonatal pain, agitation, and sedation scale (N-PASS); cry, required oxygen, increased vital signs, expression, sleeplessness scale (CRIES); COMFORT Scale; Douleur Aigue Nouveau-ne (DAN) scoring system, the premature infant pain profile (PIPP) is a validated pain scoring system for preterm neonates (2, 12). All of these scales are either unidimensional or multidimensional in connection with the number of parameters used.

In the past few years great research was oriented on a more objective means of pain assessment such as heart rate variability (HRV) - ANI/NIPE monitor - , skin conductance, near-infrared spectroscopy (NIRS), electroencephalography (EEG), and magnetic resonance imaging (MRI) (1.;13)

In creating the data collection system and framework for neonatal pain signaling we used a RPi board due to its low costs, size and most of all for its software support that is complex and user friendly. The need for a neonatal pain signaling system is raised by the serious impairment that arises from long exposure to pain in the neonatal period, the absence of an universal pain assessment tool, and last due to the fact that there are differences between the provider's level of training and experience in the recognition of pain (14-16).

Moreover, a cheap, feasible and objective tool is needed, reasoning by which the HR and SpO2 are sole parameters used in the created software. These parameters are also returned by each pulse oximeter and regardless the level of equipment of NICU in question, there is no need for new products to be acquired.

Conclusions

Pain as a fifth vital sign needs to be signaled, monitored and treated. The proposed framework for a neonatal pain signaling system needs future work like: a large sample of data and the use of an artificial intelligence means for pattern detection would bring a solution to "painful" NICU issue.

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