Robust Continuous Camera-based Heart Rate Monitoring for the Neonatal Intensive Care Unit (NICU)

1.1 Abstract

Currently, the heart rate (HR) is measured inside the Neonatal Intensive Care Unit (NICU) using traditional contact methods, such as Electrocardiography (ECG) and Pulse Oximetry. Attaching medical sensors and electrodes to a premature infant is inconvenient, since it is painful and stressful, as well as it sometimes yields epidermal stripping for infants with sensitive skin. Recently, many camera-based contactless HR measuring methods have been proposed. These methods can be divided into two categories. The first category includes color-based methods, which extracts the HR from slight color changes appearing in the skin due to heartbeats. In addition, the Second category includes motion-based methods, which measures the HR from the tiny body motions accompanying the cardiac activity. The major drawback of color-based methods is the accuracy is badly affected by illumination changes and skin tone variation. In turn, the motion-based methods relying on the mechanical effects are robust against varying illumination and skin colors. However, they provide inaccurate results when the subject is not steady. Consequently, in this project, we aim at developing a robust real-time HR monitoring system based on robust computer vision techniques in order to merge color- and motion-based techniques. Our proposed camera-based HR monitoring system will be developed for observing and measuring the HR of premature infants in a continuous basis. To increase the robustness of the proposed monitoring system, many challenges will be addressed, such as infant motion and different skin types, in addition to illumination changes. The proposed system will be validated with wide clinical experiments, in which a number of neonates will be monitored in a realistic medical setting taking into consideration the privacy of infants.

1.2 Partners and collaborators

Egyptian Partners:

Academy for Science, Technology and Maritime Transport - http://www.aast.edu/en/index.php
The Academy, as a research institution, has broadly demonstrated its ability to create innovation potential through the different projects where they are involved as well as through the results of their researchers' work, e.g. through the papers that they publish. In this particular project case it is necessary to mention the production of two scientific articles that to some extent have induced to the project participants to draft and to impulse the present innovation project.

Advanced Computer Systems - https://www.acs-egypt.com/
This Egyptian company has a previous relationship with the Academy and they are used to work together when the scientific breakthroughs from the Academy need a complementary work in terms of software development and technologies integration. This collaboration is thus deemed necessary in cases such as the present one when the research is eminently applied and the innovation is in itself a goal in the short-medium term, where the company is asked to develop a complete software with an easy to use interface that connects to a camera allowing the processing of images, for detection and classification HR in the NICU.

University Rovira i Virgili - http://www.urv.cat/en/
The University Rovira i Virgili (URV) is the public university of the Tarragona province, in southern Catalonia. To participate into this project, as the subcontractor of the Spanish company, the research group IRCV specialized, among others, in computer vision, will be assigned. The group has participated in numerous R&I publicly funded projects in the European Framework Programme (FP7 and H2020) and other funding agencies, most of them as the led partner, e.g. Game-Abling, Gable, and others.

1.3 Work Packages and Reporting Scheme

In this project, we have **6 work packages (WP)** will be achieved in **24 months**. In order to implement all the actions described so far, we have defined **4 research work packages, WP3-WP6**, covering all aspects of the proposed research, which join **WP1 (Management) and WP2 (Dissemination and Communication)**. The detailed description of each WP is given below.

No.	Partner	Country	Main Task
1.	Arab Academy for Science, Technology and Maritime Transport (**AASTMT**)	Egypt	WP1: Project Management WP3: Motion and Video magnification
2.	Advanced Computer Systems (ACS) (**Egyptian Company**)	Egypt	WP6: Development of a software for HR monitoring
3.	**Spanish Company**	Spain	WP2: Dissemination & Communication WP4: Video analysis **(URV will do that)** WP5: System Integration

1.4 Work packages of SPAINSH COMPANY

WP Number	**2**	**M1 – M24**
WP Title	**Dissemination, Communication & Exploitation**	
Lead Beneficiary	**SPANISH COMPANY**	
Objectives: The main objective of this WP is to disseminate as wide as possible our research results, and at the same time, educate the public about the pressing issues we are trying to resolve.		
T2.1: To disseminate as wide as possible the project research results, and at the same time, educate the medical community about the pressing issues that partners are trying to resolve. T2.2: To manage a web-site for sharing the project outcomes and data repositories between the partners. T2.3: IPR & Exploitation activities execution.		
Description of Deliverables D2.1. Deployment of the public website (M3) D2.2. Reports on dissemination and communication activities (M6, M12, M18, M24) D2.3. Reports on exploitation activities (M18, M24)		

WP Number	**4**	**M2 – M12**
WP Title	**Video analysis**	
Lead Beneficiary	**SPANISH COMPANY (to be subcontracted to the URV)**	
Objectives: The main objective of this WP is to develop face detection and tracking algorithms.		
Task 4.1. Implement fast and accurate face detection algorithm using deep learning models Task 4.2. Develop fast face tracking algorithm using deep learning Task 4.3. Develop a ROI selection algorithm taking into account the face rotation, translation and scaling		
Description of Deliverables D4.1. Face detection algorithm (M6) D4.2. Face tracking algorithm (M8) D4.3. ROI selection algorithm (M12)		

WP Number	**5**	**M12 – M20**
WP Title	**System integration**	
Lead Beneficiary	**SPANISH COMPANY**	
Objectives: The main objective of this WP is to integrate all the new developed algorithms into a new CAD system for HR monitoring for the NICU.		
Task 5.1. Integrate the developed color-based and motion-based HR monitoring algorithms adaptively Task 5.2. Develop a fusion algorithm to cope with the challenge of the infants' motion Task 5.3. Implement the system (SW & HW) on an embedding platform suitable for the NICU Task 5.4. Signal reconstruction and HR calculation		
Description of Deliverables		

D5.1. Integration of the developed color-based and motion-based HR monitoring algorithms (M15)
D5.2. Fusion algorithm to cope with the challenge of the infants' motion (M18)
D5.3. Embedding platform (M20)
D5.4. Signal reconstruction and HR calculation (M20)

1.5 Budget

At this moment is not 100% defined the project budget of the Spanish company, but we think that around but not less than 200.000 euros could be a good amount. This budget includes the R&I tasks to carry on within the Spanish company (including personnel expenses) and also the cost of subcontracting the URV. But as said, this is to be defined and established later on when all the activities are clearly distributed.

A comment to do at this stage is that the Dissemination and Exploitation activities are not eligible expenses from the Spanish funding agency CDTI. That means that their costs will be really low, however we don't want to remove the WP because it gives more power to the international proposal.

1.6 Contact details:

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