



CIRUSS Platform: Surgery Patient Empowerment by Stress and Anxiety Monitoring

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Abstract

In this paper, we present the CIRUSS software platform that has been developed within the framework of the Phase 2 of the pre-commercial procurement (PCP) for the Horizon 2020 STARS project. STARS-PCP aims at developing novel personalised solutions for reducing stress related to surgical procedures. CIRUSS is an integrated, scalable, sustainable and technologically adapted solution that aims to response to present and future needs of the European healthcare systems in relation to stress and anxiety management for surgery patients. Among the different functionalities included in CIRUSS, the solution integrates a tool for detecting the stress and anxiety by joint processing of voice, face and heart-rate of the patient. As a side product, a dataset of patient video interviews has been designed and acquired. This dataset has been used to assess the performance of monomodal stress detection systems as well the multimodal approach.

Index Terms: stress and anxiety detection, patient journey, voice analysis, machine learning

1. Introduction

Stress and anxiety are part of human existence. All people feel stress and anxiety in a moderate degree, as an adaptive response. It is important to understand stress as a feeling or an emotional state that help us to face stressful everyday situations. However, stress and anxiety in patients who must undergo surgery involves a significant negative emotional state, generating a physiological activation in the preparation of the organism to cope with the perceived danger, which can impair the correct development of the surgical procedure. As a result, stress causes an increase in postoperative pain, greater need for painkillers and prolongation in hospital stay days [1, 2]. All these factors have a direct impact on the cost of care and health system sustainability.

The Horizon 2020 funded project named STARS “Empowering Patients by Professional Stress Avoidance and Recovery Services” (<https://stars-pcp.eu/>) openly challenged the industry and research sectors to develop novel personalised solutions aimed to reduce stress related to surgical procedures. Reduction of the stress, experienced by patients, will lower the harmful side-effects of sedating drugs, shorten hospital stay, shorten recovery times and relieve carers and clinical staff from continuous assistance. STARS, whose consortium is composed of five leading European hospitals, started in January 2017 and will end in October 2021.

STARS Pre-commercial procurement (PCP) looked for the

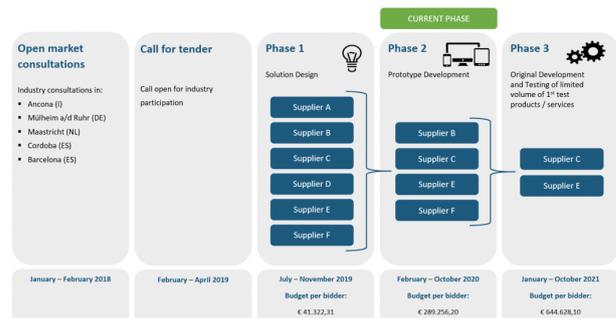


Figure 1: STARS Pre-Commercial Procurement consists of three phases (extracted from <https://stars-pcp.eu/pcp-phases>)

procurement of research and development of new innovative solutions before they are commercially available. STARS-PCP involved different suppliers competing through different phases of development (see Figure 1). Risks and benefits are shared between the procurers and the suppliers under market conditions.

The Spanish company Bahía Software is one of the Phase 2 awarded suppliers to the STARS-PCP with a software solution named CIRUSS Platform (hereinafter, CIRUSS).

Next, the main components of CIRUSS are described, along with a preclinical study on automatic stress-anxiety detection.

2. Description of CIRUSS Platform

Although stress and anxiety can manifest in the different stages of the surgery patient journey, each patient will manifest stress in a more prominent way or another according to their basic psychology. There are never two identical situations or patients. Patients are extremely diverse, and so are the unique constellations of psychological problems people experience during the surgical process. Patients’ symptoms of stress or anxiety may look very different from another patient’s. Therefore, while certain types of stress reduction technologies may be deemed effective for some patients, they likely do not work equally well for all individuals, and that is why patients demand innovative interventions for stress reduction. Among the stress reassuring intervention strategies, the CIRUSS team has dedicated big efforts to the development of remote stress monitoring technologies. Access to high-quality stress monitoring data is compulsory to later take the right decisions about stress reassuring interventions.

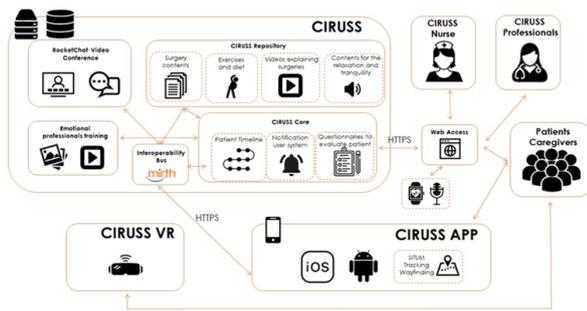


Figure 2: Overall description of the CIRUSS platform.

Constant innovation on new assessing stress solutions in patients is of paramount importance. Real-time stress monitoring still represents today a major research challenge. There are different approaches to measure stress on patients, some of them more behavioural and others more biological. By these, we mean that some answers to the challenge try to understand how the individual is behaving, e.g., body language, while the latter approach relies more on measuring specific personal body parameters which can provide an indicator, e.g. high blood pressure as a potential indicator of stress.

Considering all the current challenges, our team has been working on the development of an integrated, scalable, sustainable and technologically adapted solution called the CIRUSS Platform (see Figure 2) that aims to better contribute to the stress and anxiety management of patients. We are aiming to build a flexible modular solution which

- can be easily integrated into existing ICT systems of a private, social and medical nature,
- can be tailored to the use and needs of the patient and other end-users, and
- incorporates a comprehensive set of intelligent functionalities for the assessment and management of stress in surgery patients.

The CIRUSS software platform intends to provide a comprehensive solution to cover the several gaps in surgery patient's journey. The added value offered to patients will start with

- providing valuable information to the patient, for patient empowerment and through the entire Patient Surgery journey. Firstly, CIRUSS will contain videos and materials to explain surgeries and patient surgery journeys. Secondly, CIRUSS will provide stress reassuring content (audios, videos, and materials based on Virtual Reality (VR)) to reduce stress in patients. Importantly, these materials will be based on stress reduction and online Cognitive Behavioral Therapies.
- evaluation of personalized patient stress patterns through wearables and advanced speech recognition technology.
- access to physical exercise perioperative programs and contents to promote exercise and good nutrition in surgery patients.
- indoor positioning technology to guide patients to specific points within hospitals and to inform caregivers about the position of their relative in the hospital in real time.



Figure 3: Functional modules of the CIRUSS platform.

- videoconference services with the health professional designed by the Hospital. The videoconference service will be adapted to health professional preferences.

This platform consist of ten functional modules depicted in Figure 3. Some of the current challenges associated to stress and anxiety in surgery patients could be partially covered by them:

- improvement on the assessment of stress and anxiety in surgery patients.
- improving communication between the patient and health professionals by providing information appropriate to the patient's needs.
- reduction of cases of pre- and postoperative complications and adverse pathophysiological responses caused by stress.
- reduction of drug consumption and medications during the complete patient journey
- reduction of the time to return to daily routines.

3. Pre-clinical research study

As it was discussed before, the development of a system that automatically detects stress and anxiety is a challenge for the research community. Machine learning techniques could be applied if in-task data were available. That is why, in this project it was decided to conduct a preclinical research aiming at developing a non-intrusive technology that could serve to remotely assess stress in surgery patients. This study includes the design and acquisition of a dataset of video interviews with actual patients. Patient heart-rate was also recorded in order to be able to jointly process the voice, facial expression and heart rate of the patient.

This study has been conducted by researchers of the "Fundación Biomédica Sur de Galicia" and members of two different research groups of the University of Vigo. The data acquisition was performed in the Hospital of Ourense (Spain) and involved the recruitment of 65 patients under different surgery interventions (oncology, traumatology, etc). Currently, the dataset is being evaluated in order to determine stress levels (to collect samples after the surgery is also envisaged). This evaluation includes:

- the analysis of patient's stress levels by standard psychological instruments: Hospital Anxiety and Depression Scale (HADS), Ámsterdam Preoperative Anxiety and information Scale (APAIS) and Visual Analogue Anxiety Scale (VAS-A or EVA-A in Spanish)[3].

- classification of patients using the above mentioned psychological instruments in two groups: stressed and non-stressed using validated thresholds as a gold standard. Currently, the selection of the gold standard is still an open question.
- evaluation of patient's stress level using a salivary cortisol test [4].
- evaluation of heart rate variability(HRV) measures using the RHRV software package [5, 6, 7]: standard deviation of RR intervals (SDNN), inter-quartile (3rd and 1st) difference (IRRR), proportion of adjacent RR intervals differing by more than 50 ms (pNN50), standard deviation of differences between adjacent RR intervals (SDSD), square root of the mean of the squares of differences between adjacent RR intervals (rMSSD), median of the absolute differences between adjacent RR intervals (MADRR), HRV triangular index, calculated as the integral of the intervals histogram divided by its maximum (HRVi), approximate entropy (ApEn), and parameters SD1 and SD2 obtained from the Poincaré plot. SD1 is usually calculated as the standard deviation of the points perpendicular to the line of identity, and SD2 is calculated as the standard deviation along the line of identity.
- evaluation of patient's stress level by processing his/her speech. This analysis is based on iVector technology [8]. i-vector can be considered as a speech embedding that preserves the spectral patterns in the speaker's voice that allow the distinction between patient with and without stress and anxiety.
- evaluation of Ekman basic facial emotions using Sightcorp Emotion Recognition¹ software. The relevant categories for this project are Fear and Surprise.
- development of fusion strategies that combine the output of individual classification systems.

The purpose of this research was to explore the applicability in real clinical conditions of a standardized patient interview for stress evaluation including voice recognition, HRV and facial emotion recognition. After patient classification using international gold standards (HAD, APAIS and VAS-A) the sample was classified in two groups (stressed and non-stressed) and after normalization of the outputs of the different experimental measures, ROC curves were calculated for each measure and combining the best variables (Fusion). Fusion score showed an Accuracy of 0.777 and AUC (Area under the curve) of 0.800 (i.d. Fusion score (Fear, Surprise, MADRR, ApEn and Voice) classified correctly 80% of cases). After these promising results, challenge now is to explore the external validity of this approach to automatically and remotely evaluate psychological stress during the different stages of the patient's journey. The algorithms and mathematical models developed in Phase 2 of the STARS PCP project are now being integrated into the CIRUSS platform for this study.

4. Discussion and Future Work

CIRUSS Platform is being under evaluation by the STARS consortium. Overall, the preclinical research and the software developed (integrated into the CIRUSS platform), can offer significant novelty to the anxiety and stress monitoring field. More-

¹<https://sightcorp.com/emotion-recognition/>

over, they can also provide recovery services through the entire surgery patient journey.

In case of being selected for Phase 3, CIRUSS will be verified and compared in terms of performance (interoperability, scalability, etc.) with other alternative solutions. This evaluation will be carried out in real-life operational conditions of the targeted public service.

5. References

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