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Wavelet Scattering Transform Multimodal Signal Analysis for Physiotherapy Pain Recognition

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Abstract

Facial treatment is a successful but uncomfortable surgery. The physiotherapist needs to know how much pain you are experiencing in order to modify your therapy and prevent tissue damage. Due to the subjectivity of a self-report and the need for automated pain-related reaction assessment in physiotherapy, we have created a method. We calculate the feature vector, which includes the coefficients of the wavelet scattering transform, using a multimodal data set. Three levels of reaction are distinguished by the AdaBoost classification model (no-pain, moderate pain and severe pain). Our survey makes the assumption that each patient will respond to pain differently and be more or less resistant to it. The outcomes reflect how each patient experiences pain differently. Additionally, they demonstrate that binary recognition is outperformed by multiclass evaluation.

Keywords: Physiotherapy • Pain monitoring • Pain assessment

Introduction

Pain is a distressing sensation that is caused by sensory, emotional, cognitive and social aspects of actual or potential tissue damage. These aspects point to the subjective nature of pain. Different reactions in patients can be triggered by the same stimulus that has the same duration, source and location. As a result, pain should be evaluated in a personal context and with meaning rather than through numerical measures like pain intensity ratings or pain threshold levels. In addition, a few populations of patients, including young children, people with intellectual disabilities, critically ill or unconscious patients and adults with advanced dementia, may have difficulty self-reporting pain. Patients can self-report pain in these situations using other sounds, gestures, head positions, or eye blinks, but the information they receive may be skewed due, for example, to a clinician's lack of experience or uncertainty regarding the response. Automatic pain monitoring systems were developed as a result of the difficulties associated with pain assessment.

Description

Various studies on automatic pain monitoring systems were conducted. They differ depending on the type of data collected, the source of pain and how the patient's subjective pain rate is measured. Numerous of them were based on data sets that were freely available. The BioVid Heat Pain Database contains information from 90 healthy adults. The calibration procedure and a carefully planned set of four-level thermal stimulation served as the foundation for the experiment. The following biopotentials are included in the database: electroencephalography (EEG), electrodermal activity (EDA), electromyography of the corrugator, zygomaticus and trapezius muscles (EMG) and electrocardiography (ECG). The video of subjects countenances and profundity maps were additionally obtained. In, a method was presented for continuously estimating pain intensity in a person-independent setting. The authors emphasized that the BioVid Databases pain recognition is effective without personalization. Both video features and biosignals were used. In a recurrent neural network-based regression algorithm was presented. For use in the X-ITE Pain Database, a collection of various modalities was obtained [1].

Thermal video data and audio signal are also included, in addition to ECG, EMG, EDA, face and body video. In addition, the survey utilized two pain sources: electrical stimuli and heat. Short/phasic stimulation versus long/tonic stimulation were identified in. Additionally, the efficacy of combining various modalities was tested. The research is still ongoing despite the fact that the database is relatively recent (2019). The UNBC-McMaster Shoulder Pain Database gathered information from 129 people who had shoulder pain. Eight motion tests were assumed by the study plan. While a physiotherapist moved the patient's limb during the passive tests, the patient was in a standing position during the active tests. After the examination, a self-report and an offline independent rating based on a scene video were used to evaluate the pain. Additionally, video of the face was gathered. The authors of this paper proposed using a convolutional neural network (CNN) for pain intensity regression. Face videos spatiotemporal information was utilized in. The descriptors performance on the BioVid and UNBC-McMaster databases were compared by the authors [2].

The need for pain monitoring in physiotherapy seems to be addressed by research on EmoPain and UNBC-McMaster. Using face activity descriptors, we were able to estimate the level of pain experienced by patients with shoulder pain during motion tests. The authors state that the accuracy is 92% for a two-class problem. Patients with chronic musculoskeletal pain and healthy participants were examined in. Sit-to-stand and full trank flexion exercises were part of the study protocol. Using kinematic and EMG features, the authors were able to identify three-class pain levels with an accuracy of approximately 70–95%. Patients with chronic pain were found to change their approach to exercising—for example, by using different parts of their bodies out of fear of hurting themselves. As a result, body movements reflected protective responses to pain. The efficacy of self-exercise-based therapy is strongly linked to the emotional state (such as fear of pain, anxiety, or demotivation. Manual therapy is superior to physical exercise for a number of reasons. During physical exercises, the patient sets his or her own parameters, which could affect how bad the pain is.

As a direct intervention in the patient's tissue, facial therapy heavily relies on the physiotherapist's intuition and experience. Because the patient cannot control the external source of the pain, protective behaviors do not occur. In

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addition, it was observed that pain typically arises unexpectedly during this particular procedure. It renders the aforementioned methods for assessing pain inapplicable to fascial therapy. It is one of the treatments used to treat pain syndromes of the musculoskeletal system that are caused by overload (mostly because the position has to be held for a long time. Its purpose is to loosen up the muscles and make them more flexible. Point pressure or deep rubbing, along with a slow movement along the muscle fibers, are used to achieve these goals. It increases tissue oxygenation and thus improves blood circulation. The therapy course can be thought of as an individually selected set of variable stimuli that the physiotherapist transmits through their hand in terms of strength and plane. It is necessary to warm up tissues from the superficial to the deeper ones during its performance. The stimulus strength and intensity are gradually increased to produce this effect. The procedures force shouldn't go above the range that could hurt the patient. Nociceptive pain information is the only measure that can be a real-time feedback on the intensity of the therapy in a therapy that is not assisted by a pain monitoring system [3].

This measure is connected with rapid behavioural responses like grimacing, bracing and sighing. Patients who are resistant to treatment run the risk of sustaining tissue damage and sensitive patient reactions, both of which could have a negative impact on the therapy's success. As a result, utilizing an automated pain assessment system may aid in the therapy's safe and effective delivery. Additionally, such a system may assist in avoiding the patient's annoyance of numerous requests regarding perceived pain intensity. To the best of our knowledge, there has not yet been any research done on pain-related reaction monitoring during manual physiotherapy. This study aims to develop a facial therapy-applicable pain-related reaction (PRR) assessment method. During physiotherapy, patient data are acquired and synchronized using a multimodal setup that was designed and implemented. A vector that is subjected to a classification procedure that enables the detection of changes in the PRR level that may not be visible in every registered signal is produced by utilizing an advanced signal analysis technique followed by feature extraction in the time and frequency domain. This enables the detection of such changes. The pain-related changes in various signals appear differently in different patients. As a result, a patient-centered approach has been developed to differentiate between no pain, moderate pain and severe pain [4].

The following is how the paper is laid out: The methods for the PRR assessment, including feature extraction from synchronized, multimodal data and classification methods, are described in the following section. The findings of the study are presented. Finally, we compare the findings to those of previous studies and discuss the findings taking into account the system's intended application in fascial therapy. Additionally, we present plans for future work. To the best of the authors knowledge, PRR monitoring in fascial therapy has not been attempted due to the extensive research on automatic pain recognition. The fascial therapy procedure is dynamic, whereas research on the BioVid database, for instance, takes into account a detailed study protocol that includes a growth rate and the duration of the temperature stimuli. On a specific point on the neck or arm, the therapist adjusts force, pressure duration and pressure plane based on tissue and patient feedback. As a result, the patient's reaction is not known in advance. In addition, it is challenging to evaluate the amount of energy that was imparted to the patient or even to compare the progression of one therapy to another. All of this makes it impossible to plan similar experiments on patients [5].

Conclusion

Patients individual reactions were observed. Some of them did a lot of facial expression while others showed almost no emotion. Although some single modalities appear to adhere to the PRR level well, their reliability may vary. EDA, for instance, changed noticeably when pain started, but the signal also shows how the brain responded to emotions. As a result, PRR assessment seems to rely heavily on the use of feature fusion and the multimodal dataset. Aside from that, it's important to note that most of the experiments used one-patient-out rather than 10-fold cross-validation. It demonstrates that physiotherapy patients do not respond to pain in a flexible manner. In outcome, a subject-subordinate way to deal with this issue is wanted. As a result, we intend to create the patient-specific model in our subsequent work. The personalized model will likely increase efficiency and make it possible to examine the subjective patient response in greater depth. In addition, in manual physiotherapy, an attempt to recognize more than three classes may perform better and more accurately reflect the nature of pain.

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Conflict of Interest

None.

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