Ph.D. in Information Technology:

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PEZZOLI MIRCO – XXXIII CYCLE

Thesis: Space-time Parametric approach to Extended Audio Reality (SP-EAR)

Supervisor: Prof. Augusto Sarti

Abstract

The extended reality field is rapidly growing, primarily through augmented and virtual reality applications. In this context, Extended Audio Reality (EAR) refers to the subset of extended reality operations related to the audio domain. In this thesis, we propose a parametric approach to EAR conceived to provide an effective and intuitive framework for implementing EAR applications. The main challenges of EAR regard the processing of real sound fields and the rendering of virtual acoustic sources (VSs).

We introduce a novel parametric model for sound field representation based on few parameters. The proposed model allows both the navigation and manipulation of a recorded sound scene. The main feature of our solution consists in modeling the acoustic source directivity directly through the parameters of the representation.

Moreover, we can seamlessly implement virtual sources within the same parametric representation enabling EAR. We studied the VS implementation through a case study. In particular, we focused on the VS implementation of violins. Different solutions are outlined according to their invasiveness ranging from the measurement of historical instruments to vibroacoustic simulations of violin models.

Lastly, through a proof-of-concept simulation, we showcase the benefit of the proposed parametric approach to EAR.

Paracchini Marco Brando Mario – XXXIII CYCLE

Thesis: REMOTE BIOMETRIC SIGNAL PROCESSING BASED ON DEEP LEARNING USING SPAD CAMERAS

Supervisors: Prof. Marco Marcon

Abstract

Remote PhotoPlethysmoGraphy (rPPG) allows the extraction of cardiac information just by analyzing a video stream of a person face. In particular, the blood flowing in the vessels underneath the subject’s face introduces variations on the light intensity reflected by the skin that could be analyzed in order to obtain information about the subject’s heart activity. In this research, the adoption of a rPPG application in an automotive environment is investigated in order to monitor, in a non invasive fashion, the driver's health state and potentially avoid accidents caused by acute illness states. The main goal of this work is to study and develop a rPPG system able to estimate numerous biomedical measurements in real time and in a dependable fashion. Moreover, this work explores the possibility of adopting a SPAD (i.e. Single-Photon Avalanche Diode) array camera instead of traditional RGB camera. In order to compensate for the SPAD camera's low spatial resolution, a novel facial skin segmentation method, based on a deep learning model, is proposed. This method can precisely associate a skin label to each pixel of a given image depicting a face even when working with low resolution grayscale face images (64x32 pixel) and is able to work in presence of general environment condition regarding illumination, facial expressions, object occlusions and regardless of the gender, age and ethnicity of the subject. In order to perform and validate biometric measurements with a SPAD camera and compare it to estimations that could be obtained from a traditional RGB camera, multiple experiments have been conducted using a portable ECG device for reference. Moreover, some metrics were developed in order to monitor the dependability of the heart rate estimation and detect situations where an optical solution, such as rPPG, could fail. Finally, a rPPG application has been developed able to run in real time on a small ARM device equipped on a car. After receiving data from the SPAD camera, it is able to execute in real time the deep learning based pulse signal extraction and analyze it in order to constantly monitor the driver's health condition by estimating multiple biometric parameters.

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