Biologically driven musical instrument

eNTERFACE
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Abstract:

This project proposes to use the analysis of physiological signals (EEG, EMG, heart beats…) to control sound synthesis algorithms in order to build a « biologically driven musical instrument ».

1. Project objective

The main goal of this project is to use biophysical signals processing analysis to drive a musical instrument. So far at most basic level, the system should contain at least fives components:

1. Sensors for determining user intents.
2. Analysis tools to extract information from the EEG, EMG, ECG.
3. A Dictionary to convert biophysical features in sound synthesis parameters.
4. Real-time sound synthesis/processing modules
5. An underlying computational architecture to integrate these components and play.

An important task of our work will be to establish the best mapping between sound synthesis parameters and analyzed physiological signals.

2. Background information

Since the first age, man plays music. Every civilization has developed these own music and these own instruments. Advancements in science and computer enable now musicians to use computer and sensor-based instruments to perform music (Tanaka, 2000). They play with position, heart beats, electromyogram (EMG), etc. (Nagashima, 2003; Tanaka, 2002). Advancements in Brain-computer Interface (BCI) research show that basic control of the brain thoughts is possible (Wolpaw et al., 2002). Therefore, in this workshop, we want to combine ElectroEncephaloGram (EEG) with EMG, ElectroCardioGram (ECG, Heat beats) and uptodate computer program.

3. Detailed technical description

Technical description

The project is divided in two parts :

- Data acquisition, analysis, fusion and interpretation

  - 3 types of data are considered with associated captors: ECG data, the musician will probably not have too much influence on these data, they could control the rhythm; EMG data will be directed by the musician; EEG data could be splitted between physiological rhythm with no influence from the musician and data influenced by the musician.
  - Targeted signal analysis in order to extract to relevant feature. The aim of this part is to define what kind of features need to be extracted from each kind of signal and how they should be extracted. For example on the EEG signal, we can look at change in mu rhythm and how they can be detected.

- Sound synthesis and interaction with the physiological signals

  - For the creation of sound, two approaches will be considered :

    - “sound effect” approach, where an existing sound material is transformed. We could act on basic features of sound (volume, pitch, tempo, spectral content…) or experiment more complex analysis/synthesis methods. Working on sound localization might give interesting results.
    - “sound synthesis” approach : we will explore several sound synthesis techniques used to produce different types of sound (harmonic sounds, sound textures, singing voice…).

  - To establish correspondence between physiological signals and sound synthesis parameters, we will study existing virtual musical instruments, especially the mapping between gesture and sound parameters.

Resources needed : facility,equipment software, staff etc…

- Equipment :
  - One fast computer per participant.
  - EEG cap and senors to capture signals with the respective AD (Analog-Digital) box.
  - EMG and ECG sensors.
  - UCL lab audio equipment (10 active loudspeakers, 1 subwoofer, audio device)
  - One armchair

- Facility : two large rooms with network and controlled light conditions.
- Software : Linux system (Debian or Ubuntu), Internet, Matlab, EEGLab, OpenInterface and MedicalStudio + Musical software + real-time sound synthesis software (Max-MSP, Pure Data, CSound).
- Staff : system administrator.

Project Management
UCL (J-J. Filatriau, Q. Noirhomme)

4. Work Plan and implementation schedule

A tentative timetable detailing the work to be done before and during the workshop

- April : just after the team selection, start of a data acquisition campaign, in order to have data ready for the workshop start.
- July 18th : kick-off day with all participants.
- Parallel work of all sub-teams (physiological signals analysis team, sound synthesis team...)
- Coordination points every few days.
- Adaptation of software tools to local conditions and application
- Software integration
- HCI Evaluation Framework – Tests
- Software cleanup and packaging for later reuse
- Redaction of report and demos (live demos and videos)
- Final presentation

5. Benefits of the research

At the end of the workshop, a virtual musical instrument driven by EEG, ECG and EMG should have been produced. This instrument might be presented at related scientific conferences (NIME, DafX, ICMC…).

6. Profile of team

a. Project leader : Prof. Benoît Macq (UCL)

Benoit Macq was born in 1961. He is currently Professor at Université catholique de Louvain (UCL), in the Telecommunication Laboratory. He is teaching and doing his research work in image processing for visual communications. His main research interests are image compression, image watermarking and image analysis for medical and immersive communications.

b. Staff proposed by the leader : Jean-Julien Filatriau and Quentin Noirhomme (UCL)

Jean-Julien Filatriau is research assistant at Communications and Remote Sensing Lab. (UCL) since October 2004. He is working on Tifanis tele-immersion project. In parallel, he is pursuying research on synthesis of sound textures and control of sound processus by video-based motion analysis, in collaboration with Prof. Daniel Arfib (Laboratoire de Mécanique et d'Acoustique, Marseille).

Quentin Noirhomme is research assistant at the Communications and Remote sensing laboratory (UCL). His main research interests are Brain Computer Interface, physic based model of a human brain and EEG.

c. Other researchers involded in the project

People interested in joining the sound synthesis team have to present an expertise in the related field (sound processing/synthesis, human-machine interaction…). An experience in programming in a sound synthesis environment (Max/MSP, CSound, Pure Data) is also required. Our approach will be explorative so curiosity and creativity are welcomed. Finally, a musical education would be an interesting asset.

Experienced researcher(s) in the area of EEG analysis.

7. References

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