

The sound of emotions: Extracting the emotional content of handwriting sounds

Luxembourg (together with Israel, Mexico, Germany, UK, USA)

<p><u>Quote:</u> "This study presents a novel approach to optimize expressive writing therapy for PTSD by utilizing audio analysis of the writing process. Preliminary findings demonstrate that sound recordings from standard devices can reliably detect handwriting characteristics and emotional states, which can be observed in the different analytical methods used, as well as in the AI models developed."</p> <p><u>Origin of the quote:</u> Concluding statement from our project paper.</p>	<p style="text-align: center;">Photo of the Project <i>Please do not copy the picture here- send it separately, in .jpg format</i></p>
<p style="text-align: center;">Photo of projector <i>Please do not copy the picture here- send it separately, in .jpg format</i></p>	<p style="text-align: center;"><u>Vision:</u> Help to improve PTSD therapies by extracting emotional content of handwriting sounds, through the implementation of machine learning algorithms and audio analysis techniques.</p>
<p><u>Bio of projector:</u> Bartłomiej Nowak graduated from the European School of Luxembourg I in 2024. He will be studying Computer Science and Engineering at the Technical University of Delft in the Netherlands.</p>	<p><u>Activity:</u> Expressive writing has demonstrated efficacy across various psychiatric applications, as evidenced by multiple studies. Crucial to its effectiveness is the complete privacy of the writing process, posing challenges for noninvasive evaluation.</p>

Bartłomiej participated 3 times at the National Jonk Fuerscher Contest, in 2024 being awarded the honor of attending the Weizmann International Summer Science Institute for his design of an autonomous robot

His interest lies mainly in computer science, especially the field of machine learning, which was the focus of most of his projects. However, his work is not only limited to AI, as Bartłomiej also worked on robotics projects, computer graphics, websites, simulations, GUI apps and more, always being open to expanding his knowledge.

During our study we worked on techniques in assessing a patient's emotional state through the acoustic properties of their writing. Based on prior research it was clear that emotions influence the duration and frequency of pauses. Therefore, the efficient and accurate detection of these features became a key goal of our work. The problem was approached from two sides, one creating analytical solutions, the other based on deep learning models.

Regarding the former, we tried to detect pauses by analyzing the energy of the acoustic signal, which worked well for audio with little noise. Another method was the summing of spectrogram intensities, we tested this method on a sample with positive emotions, and on one with negative. It showed a higher frequency and longer duration of pauses in the file with negative emotions than with positive, serving as evidence for the importance of pause detection.

As the first step in the deep learning approach, we created a sizable dataset containing various audio files, labeled "writing" or "no writing", which would be used in the training of our classifier. One of our most successful models was created using *transfer learning*, which is a method of using a pre-trained model and using its parameters for training a new one. This allowed us to build upon previous research, decrease training time, and make the most of the data we had. In the case of our study, we choose YAMNet as our pre-trained model, as it is a state-of-the-art audio classifier. This method achieved stellar results, with an accuracy of over 98% during tests on clean data. However, problems again arose when testing on noisy audio, speech, being a strong signal, was especially problematic for the model, decreasing the accuracy to approximately 50%.

There is still a lot of work to be done on this matter, especially regarding noise in the audio. Nevertheless, we are optimistic about the long-term goal of creating an easy-to-use system that psychologists and doctors can begin to implement these types of therapies to treat PTSD safely and reliably and thus obtain better results in terms of the evaluation and treatment of this disease, thanks to this, we will be able to generate a positive impact on the society that suffers from this cognitive disorder.

Project website address: (will be available after the end of the full programme - 8th of August)