# Source Separation

## 1 - Goal

Intensive Care Units (ICUs) and Emergency Rooms (ERs) are extremely noisy and chaotic places in hospitals. Reducing the chaos is the focus of a different project in this portfolio. Here I focus on a project aimed at reducing the difficulty that both patient and clinical staff have with hearing the right sounds, amongst many other sounds of equal or greater volume. Specifically, I experimented with a known technique called source separation, but as applied to a hospital setting.

## 2 - Innovation

ICUs and ERs are filled with medical equipment that all produce various sounds. Some of these sounds are regulated because the equipment has to generate the sound. For example, a heart rate monitor must produce beeps corresponding to a patient's heartbeats. But whether required or not, clinical staff will need to be able to hear specific alarms from a distance, as they cannot have eyes on every patient. However, a lot of the sounds are not relevant to anyone clinician. Patients are divided across clinicians, and each clinician must pay attention only to a subset of sounds. In addition, an ICU and ER will also be a cacophony of voices. This is perhaps truer for an ER, but an ICU hallway will still have clinicians and family members converse in and outside rooms, in hallways, and at their stations. Again, only certain voices are relevant to anyone person. Finally, from the patient's point of view, most sounds are irrelevant, even those produced by the equipment they are attached to. Similarly, they only really need to comprehend and understand things that are said to them, not necessarily to anyone else. Finally, perhaps they would prefer focusing on the sound from a TV for distraction, which is hard given the sounds that fill their rooms already. In all the above examples, the real solution seems obvious: both patient and clinician should have some ability to tune in to specific sounds or voices while others are muted. And this technique already exists: source separation.

## 3 - ICA source separation

Independent Component Analysis is an algorithm that uses the statistical structure of a signal to divide it into separate sources. In other words, it is a mathematical technique to unmix several sounds into the different sources it is comprised of. I implemented this technique in a Unity-based simulation to demonstrate its usefulness.

## 4 - Simulation

Using Unity and 3D LEGO pieces, I designed a hospital room containing various pieces of sound-producing equipment and is connected to a hallway producing background noise. In the simulation, we take on the perspective of a patient being addressed by a clinician, with plenty of ambient noise and sound emanating from all directions. In the first video embedded below, you can see and hear how many different sounds reach the patient from all sides and that it is hard to understand the doctor, even when facing in their direction. However, the same conversation becomes much more intelligible after we apply source separation.

## 5 - Impact

If a source separation algorithm can be implemented into an earpiece and operate with sufficient accuracy and in real-time, much in the same way our headphones have noise cancellation abilities, both patient and clinician can choose what sound(s) or voice(s) they want to be able to hear, and which ones should be muted as much as possible. In addition, by embedding context-aware artificial intelligence, such a system might itself switch 'channels' to alert a clinician of a sound or voice relevant to them that they otherwise might have missed. Finally, it can serve as a way to protect a patient's privacy by blocking a channel that contains a conversation between a patient and clinician or two clinicians discussing a patient for anyone who should not hear it.

## 6 - Technologies Used

Unity

Lego

C#

Python

Scikit-learn