

## Human-computer collaborative improvisation

As a musician and a music listener, I feel that improvisation shows the creative power of the human mind in a very unique way. The vulnerable temporality of a live improvisation gives it that special thrill and differentiates it from many other forms of artistic expression. Improvisation can reveal such personal feelings that one could feel awkward just listening to other musicians improvise. The musicians' self always shines through his improvisation.

This act of spontaneous creation is exciting, but some of its aspects are quite hard to describe. When you ask any musician: "What is it that makes you a good improviser?", you usually hear them talk about various skills, like being able to play fast, memorize a lot of interesting scales, pay attention to a lot of what the others are playing and so on. These are all parts of the process and a lot has been written about the techniques, scales, progressions, etc. Much less is known about the nature of the interactions between them, how they influence each other in the musician's mind, how musicians influence other musicians, or even what the role of an audience can be. We can identify a lot of different kinds of behavior in an improvised performance. But how did they come about? Why in this particular order or form?

Being a computer scientist that deals with system descriptions and algorithms every day, I got curious about what it is that's actually happening when I perform. It's difficult to imagine how much effort would be needed to formalize the thinking of a very skilled improviser with a detailed understanding of the musical theory and with thousands of musical pieces memorized, but my own improvisation skills are mostly self-taught and definitely very limited, which somehow ironically made things easier for me. My understanding of improvisation was simple and so it seemed feasible.

Today people seem to be getting close to understanding how the human mind works on various levels. Marvin Minsky's "Society of the Mind" contains a theory of the human mind that led me directly to ideas about practical implementation. Minsky sees the human mind as a result of an interaction between many simple processes he calls agents. This works well with our findings in neuroscience - we know the brain is essentially a large parallel machine where many diverse parts (brain centers) operate on information from various sources (external and internal), pass the information between themselves, store it in memory and so on. This model allows us to explore the

inner mechanism of many human activities, and in particular creative work like musical improvisation.

The three basic things I try to keep in mind when improvising are synchronization, planning and generation. Synchronization is the rhythm/temporal aspect, the tendency to keep in sync with other musicians or sources of rhythm (usually achieved by dividing time into chunks), along with related tasks like creating what musicians call "the groove". Planning (or scheduling) refers to harmony, which is usually decided beforehand since that's easier than detecting or creating it on the fly. Harmony was the last part of music to develop, and it appears that people in general have harder time developing cognitive functions for quick harmony generation or its accurate perception. Arguably the most creative part is generation, the creation of melodies. Generation seems to be the area that provides the musician with the most freedom, one that is less tied to the other two, but also perhaps the most expressive and reactive to the environment in terms of spontaneous invention.

I argue that we can describe the musician's work with regards to each of the three aforementioned properties of music quite sufficiently by dividing each one of them into a set of tasks. I started by exploring melody generation, because I felt subjectively it was the most straightforward one, but I'm sure others might feel differently (e.g. drummers). The Melodina program I created substitutes the musician in a part of the generation process. It allows the human player to decide on the harmony and the rhythm of the improvised piece, along with some meta-characteristics of the melody itself (rising/falling, random/smooth, high/low registers...). All this is controlled in real time via a standard MIDI keyboard in a familiar fashion, however the presence of the artificial agent distorts both the musician's perception and the result itself in a peculiar way. The software agent creates the melody based on all the information put in by the user and its internal memory via a process that involves both concrete rules and random decisions. Turns out, even with the computer controlling arguably the most crucial part of the process, the resulting improvised melodies are remarkably close to what I might have played myself. The real-time nature of the whole "instrument" changes the way the musician thinks (and plays) because the ways of how to control the results change and the instrument gives a different feedback from what standard instruments provide.

Although some of the other tasks involved in the improvisation process would seem to be harder to recreate using algorithms, there is nothing stopping us in trying to do so. We could slowly chip away

the human's responsibilities and keep handing them over to the AI participant, so that the conscious act of improvisation would spread over these two parties and a potential listener would have more reasons to attribute the status of the improvising artist to the software agent(s) rather than to the human player. Apart from potentially very interesting musical results and the creation of a whole new category of intelligent musical instruments, I argue that should such process work well within the musical realm, it would likely work elsewhere and so this consciousness oriented modular approach could help us understand human behavior in general.

In particular, I am interested in the way the musician's cognitive process changes when we introduce an artificial agent that substitutes some of what was previously being managed by the human mind. Whether it's a substitution or an augmentation, from artificial joints to retina-mounted displays, we've witnessed the invasion of artificial parts into the human body. It is only logical to conclude that the next area that will be "invaded" by technological advancement powered by new scientific knowledge will be the human mind, the consciousness itself. This can only be achieved by us first understanding how consciousness works.

I believe that consciousness emerges from design, and that it is not a magical property that suddenly appears when the underlying system reaches critical level of complexity. A much more useful way of dealing with consciousness is to see sentience in a whole spectrum of intensities (see Dennett's "Kinds of Minds"), as a result of cooperation (or competition) of simpler systems putting themselves upfront (due to their intentional stance, Dennett might add), because that allows us to work on incremental improvements, rather than spend time looking for the "magic trick" that turns an object into a conscious being. Whether or not our models of consciousness and/or improvisation might require tweaking or major redesign, if we are successful in our struggle to replace the human mind in some of the basic duties, we can start experimenting with combining some of them together and possibly reaching a point where the AI will begin to out-weight the human mind. Plenty of questions to answer remain. Are there any limits to this process? Will it always be possible for a human to deal with the responsibility displacement? Would a human brain develop differently if the person was to learn playing an instrument with an AI agent already built in from the start? What sort of impact would it have on the songs a person that isn't able to play a regular instrument would make?

Jan Valentin, Prague 2011