MAD Clarinet 3.0: Dialogues with my computer

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Abstract
MAD Clarinet 3.0 is an article that discusses a Static Artificial Intelligence (SAI) system, dialoguing with a clarinet performance under a Tangible Acoustic Interface (TAI) system and using the software Max/MSP. The TAI system, working through solid vibrations, enables the use of the clarinet as an interface to trigger the computer's sonic response, employing the parametrisation of the clarinet´s sonic characteristics, such as pitch and duration. This dialogue is made from the harmonic and melodic point of view, and, whereas the harmonic paths are chosen randomly – from among several possibilities – by the computer, the melodic paths are made by measuring the clarinettist preferences in real-time. Throughout the document, it will discuss the concepts, the system, the patches, and potentialities. Thus, this article arises from the junction of a clarinet – under a TAI system – with an SAI system and, from the artistic point of view, using a computer as a performative partner with an essential role.

Keywords
Clarinet · Performance · Static Artificial Intelligence · TAI

1. The Concept

1.1. Introduction

This article describes a musical performance system for a clarinettist and a computer in which the clarinet is used under the concept of a Tangible Acoustic Interface (TAI). There are two manners to observe a musical instrument: (1) a device to be played by someone; (2) a cultural artefact with historical value [1]. The second manner is when we are talking about, for example, a Stradivarius violin, where the instrument has historical value for itself. The first manner is an object – instrument – touchable and inherently tangible, and it occurs when someone uses it to achieve sonic purposes.

In this case, the clarinet is used in the traditional manner of playing it acoustically, is an interface, and

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could be augmented. In other words, besides keeping its acoustic properties, the clarinet could be augmented in various ways such as octaviated – or any other interval(s) –, reverb, delay, and distortion, among others. At the same time, through the measurement of different features using sensors of solid vibration, the clarinet sends data to trigger the computer´s response in a Human-Computer Interaction (HCI) method. This HCI allows the computer to interact with the clarinettist sonically, both harmonically and melodically.

Thus, this system approaches the performance based on three concepts: (1) the clarinet as a TAI, (2) an SAI performative system and (3) an augmented instrument. This allows the instrumentalist to control the clarinet and the computer through the clarinet in a hybrid system which works harmony layers and melody through solid vibrations while the clarinettist can choose to use – or not – the effects mentioned – adding intervals, delay, reverb, among others. This hybrid system matches what Papadopoulos and Wiggins [2] and Caramiaux and Donnarumma [3] state that an AI system/performance must be hybrid – mixing different techniques and systems to get strength points from other sources – and it should involve professional musicians. Finally, the multidisciplinary feature of this project fits the new virtuosity concept related to a hybrid era influenced by technology [4].

2. Literature Review

This literature review emphasised this article's subjects – TAI systems and probabilities systems; for this reason, fields concerning ML in music, which are not probabilities systems based on sonic capture or other subjects, will not be addressed.

2.1. The Concept of a Clarinet as a TAI

Tangible Acoustic Interface (TAI) refers to something tangible and acoustic, which acts as an interface using solid vibrations. With a TAI system, the instrument, in this case, the clarinet, can be under augmentation or used as an interface besides its traditional sonic properties. One feature doesn´t imply the other. According to Crevoisier and Polotti [5], and regarding classical musical instruments, the instrumentalist, who interacts closely with the vibration source, should combine the sonic production with the interaction through the instrument. In other words, besides the sonic production, the instrumentalist should use the instrument as an interface to communicate with the computational component. Concerning the interface concept, Shanbaum [6] mentions that the definition of interface evolved from a word which describes the communication between hardware and software to a concept in which an interface can be any technology that mediates relationships between people and artwork, influencing the movement and perception of those involved. Also, Manovich [7] confirms this evolution, stating that a Tangible Interface is something physical that could connect a human with a computer, enabling a system for Human-Computer Interaction (HCI). In this way, the clarinet, with a TAI system, can serve this connection.

There are two types of TAI systems: the active system, which is based on the absorption of solid acoustic energies, and the passive system, which is based on the solid acoustic produced [8]. Both cases can be implemented in a clarinet. The active when the instrumentalist is using the clarinet to produce its acoustic sound – for example – provoking the absorption of solid acoustic energies, and the passive, for example, whether the instrumentalist is making the Key Slaps technique – pressing the keys without blowing to the instrument, causing solid acoustic energies in the clarinet´s tube.

There are two advantages of using this TAI system in opposition to a microphone or a pickup placed in the barrel. The first is that the TAI is much less susceptible to external sound than a microphone. The difference of influence exercised between the clarinet sound is much higher than other external sources, and this difference allows the optimisation of a gate in the patch of the Max/MSP to neutralise the external sources. Whether a pickup in the barrel has the same effect as capturing the clarinet sound, the second advantage is that the TAI is more sensitive to the surface touch without changing the input levels, and any tapping or scratching on the clarinet body is traceable with this TAI system [9,10].

2.2. (S)AI Concepts

Since the Illiac Suite by Lejaren Hiller and Leonard Isaacson in 1957, AI systems have evolved in music and become more and more complex, involving several parameters. In relation to performance, the project *Ultrachunck*[1] should be approached [11,12] because it is an example of interaction between a performer – singer – and a computer. However, related to the characteristics of this article, it is worth mentioning the Markov models, which combine information for stochastic processes such as pitch, duration, onset, scale degree, and others [13,14]. One example of a combination of several aspects based on Markov models is the work constructed through a probabilities system resulting from the analyses of the work by J.S. Bach Well-Tempered Clavier, BWV 846-893 [15].

Nevertheless, MAD Clarinet 3.0. has an approach closer to what Kühl et al. [16] designates as a Static Artificial Intelligence (SAI) system. They mentioned that a SAI is a simple reflexive system that reacts through collected data based on algorithms, which is not classified as Machine Learning (ML) because it has a fixed response model. In this way, ML has two phases: (1) learning from the input data and (2) creating output and collecting live data acting or influencing decisions from previously learned structures [17].

In the specific case of Max/MSP software, the Bach Library and the Cage Library give the user several options for developing different (S)AI and/or ML systems [18,19], and it has been utilised in projects like *Comprovisador* by Pedro Louzeiro [20], in which a soloist interacts with other musicians with the mediation of computational components and through its own musical notation.

In conclusion, the SAI is an essential definition for this article because it fits the system developed.

3. The System

3.1. The Connection

The exploration of solid vibrations through a clarinet allows several places to install sensors, such as between the reed and mouthpiece, over the rubber protection for the upper teeth, a tilt sensor installed on a key, or various places along the tube – outside or inside. Due to the objectives, for which it was essential to detect the pitch and use the surface touch as a type of percussive sound, a Piezo Vibration Sensor inside the bell, as shown in Fig. 1., seems the best and easiest option. It was also tested using the same sensor between the reed and the mouthpiece and above the rubber for the upper teeth – also in the mouthpiece. However, for the system explained in this article, those places were inadequate because they were too sensitive for a passive vibration. For this project, which is grounded especially – as will be shown throughout the article – on the parametrisation of active solid vibrations, it was necessary to insert the sensor in a place less susceptible to passive vibrations.

Figure 1. A Piezo Vibration Sensor placed inside the clarinet´s bell.

This sensor had been connected to an interface – Zoom H6 – to distribute the signal to the software Max/MSP[2]. It was used to achieve this connection, a cable with a mini jack stereo – 3.5 mm – adapted to a jack – 6.35 mm – into the interface – and bare

[1] https://www.memo.tv/works/ultrachunk/ accessed on February 24, 2024.

[2] Max Signal Processing (Max) / Miller Smith Puckette (MSP) is a software developed by the company Cycling ´74. https://cycling74.com/products/max accessed on October 15, 2023.

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wire open on the other side. Finally, those bare wires were soldered to the Piezo Vibration Sensor, as shown in Fig. 2.

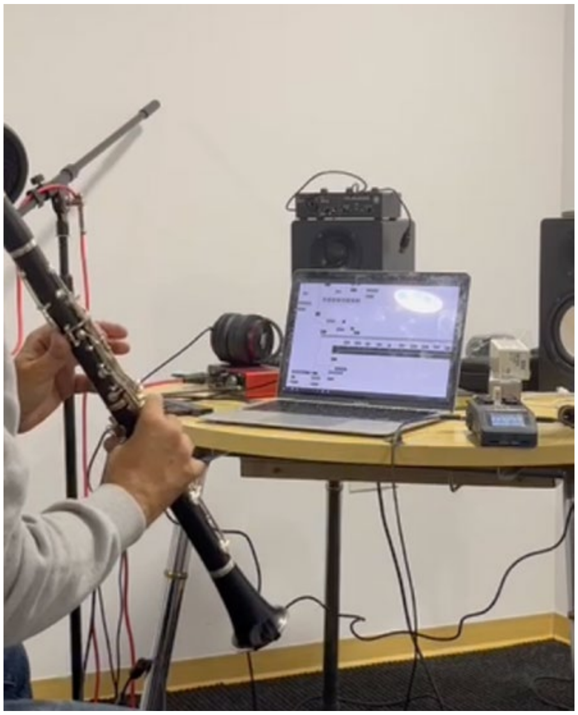

Figure 2. System working.

4. The Patches

4.1. Harmonic Patch

The harmonic patch was developed to work through the pitch capture. Thus, the patch's first system captures and decodes the capture in midi values. Each note has a midi value; for example, a C4 – middle C – is 60, a C4 sharp is 61, and a B3 is 59. In this way, if the computer gets a 60 (C4), adding four and seven to the initial value, we get the original value 60 (C4), 64 (E4) and 67 (G4), which means we get a major chord. With this system of adding values to the capture value, we get the chord quality, no matter which note is captured. Also, parameters of values were added to use the initial value in all chord positions, avoiding its use only as root.

Major	**Minor**	**Augmented**	**Diminished**	**Cluster**
Triad	Triad	Triad	Triad	Cluster
Major with major seven	Minor with major seven	–	Diminished seven	–
Major with minor seven	Minor with minor seven	–	Diminished minor seven	–
Sustain four	–	–	–	–
Sustain four with minor seven	–	–	–	–
Sustain two with minor seven	–	–	–	–

Table 1. Table of the patch´s harmonic possibilities

The harmonic possibilities are applied under some gates and randomness to avoid problems. One possible problem is that sonic chaos would be quickly reached if the capture and the harmonic system were always working. So, if sonic chaos is not the objective, using a gate based on metronome counting is possible.

Concerning the harmonic possibilities, the pre-definition is shown in Table 1, but this is not a closed list. It could be changed, but it was not designed to do it in real-time.

Figure 3. Harmonic patch in Max/MSP.

After choosing the tempo signature, it is possible to determine which beat(s) the pitch capture is on. For example, if we have chosen measures with four beats and the captures are on in the first beat, we get harmony for each measure. However, it is also possible to determine the on/off of the pitch capture randomly. The harmonic choice is made randomly by the computer. The initial value creates a bang to trigger the random choice between all the possibilities. Also, the duration of the computer sound is chosen randomly between a pre-defined value.

Other features were added to this patch, specifically, a switch to add a lower octave and/or a fifth to the clarinet sound, reverb, and delay. The instrumentalist can easily switch – on/off – these features in the patch[3].

4.2. The SAI Patch

Two parameters were used to develop this SAI system: pitch and duration. Regarding the pitch, first, a system was designed to collect data. This system calculates the difference values between the notes played in the clarinet and creates a statistic, as shown in Figure. For example, if the clarinettist plays the first part of the song Twinkle, Twinkle, Little Star, it will result in the following values: 60 (C4) – 60 (C4) – 67 (G4) – 67 (G4) – 69 (A4) – 69 (A4) – 67 (G4) – 65 (F4) – 65 (F4) – 64 (E4) – 64 (E4) – 62 (D4) – 62 (D4) – 60 (C4). The values, converted statistically, result in the following Table.

Values Variation	Used/Rounded Percentage
0	6 / 46,16%
1	1 / 07,69%
2	5 / 38,46%
3	0 / 0%
4	0 / 0%
5	0 / 0%
6	0 / 0%
7	1 / 07,69%

Table 2. Table of the variation of the value from the beginning of the song Twinkle, Twinkle, Little Star

In this specific case – shown in Table 2. –, the computer will have a 46,16% chance to repeat the previous value. In other words, if it was given a value of 60 for the computer to start its performance, and according to Table 2., the strongest possibility is the repetition of the same value, and the second one is a variation of 5 units – with 38,46% – from the starting point. It is important to note that the computer randomly determines if value variation is realised by adding or subtracting from the previous value and using a window between the values 36 (C2) and 84 (C6), approximating these values to the clarinet extension.

Concerning the sound duration, the system works similarly to the pitch. When a sign of pitch is captured, a counter is triggered to determine its duration in milliseconds. When the sign is over, or the pitch captured is different, the counter suffers a reset. Each time a reset is made, the previous value is recorded. The computer transforms all the recorded values in data to calculate the probabilities, and then the computer makes a random choice based on these probabilities. Thus, both pitch and duration result are resulted from the clarinettist´s playing.

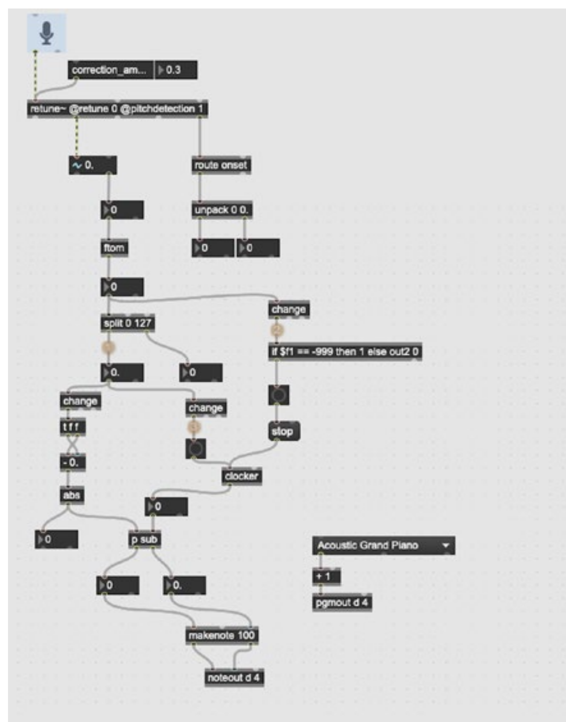

Figure 4. Melodic patch in Max/MSP.

[3] An example can be heard in the following link: https://soundcloud.com/rui-travasso/gres-de-silves?si=b85249f59ebb4160acfaa08e413a123c&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing accessed on February 24, 2024.

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Thus, this SAI system combines statistically two parameters – duration and pitch – to respond sonically in the performance through a statistic system[4].

5. Potentialities

This system allows the use of a computer as a performative partner in two distinctive ways. On the one hand, the harmonic system provides different sonic layers to complement a melody or a sonic purpose, and it could augment the clarinet with intervals, delay and reverb. By optimising the patch, different harmonies could be pre-defined to achieve other sonic paths/ambiences, adapting it to different musical styles. Also, various applications for these layers, regarding *tempo* and/or which beat(s) will be playing, could be defined, giving distinct *tempo* feelings for diversified sonic objectives. On the other hand, using this SAI system brings a dialogue to the performance, in which the computer adapts to the instrumentalist´s playing while provoking a reaction to the instrumentalist with its sound. One problem identified in (S)AI systems is related to the duration of the sounds because human expressivity slightly changes these values on what we call *rubato* [13]. Usually, the computer does not have this type of expressivity, although MAD Clarinet 3.0. does not pretend to solve this question, using a system based on milliseconds instead of a fixed one based on the metronome, mixed with a fixed value for each measure – or another regular mark – could be a way to deal with this problem.

Due to the specification concerning the capture of the clarinet sound from solid vibrations, to use this system on other traditional instruments – referring to the Western classical music tradition instruments – it is necessary to adjust a TAI system. However, the patch can work wherever the instrument is playing. In the case of MIDI instruments, they can be used without any adjustment. Therefore, the system explained in this article is not closed to a clarinet. It could be used on various instruments, and it could also be used as part of a performative group. In other words, the clarinettist – or another instrument to which this system is adapted –, equipped with this system, could perform with other instrumentalists and/or artists from different areas. This system works as an extension of the clarinet and/or the clarinettist.

Finally, the SAI system could be used from zero in each performance – not saving data from one performance to another – or the data could be saved, linking knowledge from several performances. Thus, the computer can acquire performative experience in its performative life, collecting experiences from each concert and rehearsal in a certain way, similar to an instrumentalist.

6. Conclusion

MAD Clarinet 3.0. The combination of the clarinet as a TAI and the patches brings a new interaction between a clarinettist and a computer. Somehow, the instrumentalist and the computational component are put at similar levels regarding performance using solid vibrations. Also, the clarinettist can use this SAI system from zero or create data from different performances, keeping the computer in constant apprenticeship. As a professor can shape/influence the students' minds – in a certain way – the clarinettist can manage the data transmitted to the computer, affecting its playing. As a response, the computer adds harmonic layers and learns with the clarinettist during the performance.

Despite this being a system to apply in a clarinet, the performance possibilities could go further than a duet. There are two ways to observe this from a performative point of view: (1) as two instruments – clarinet and computer – in a dialogue; (2) as one whole instrument – clarinet and computer – commanded by the instrumentalist, which in turn, is part of a performative group. Both are valid applications for using MAD Clarinet 3.0 and other options the imagination leads us to.

Lastly, it is important to state the application of the clarinet as a TAI to process its sound and to serve patches purposes. This is also a malleable system because it could be explored in several manners such as different sensors for different goals, and different positions on the clarinet.

7. Future Work

The main goal to develop the project MAD Clarinet in the future is to collect a larger amount of

[4] An example can be heard in the following link: https://soundcloud.com/rui-travasso/discordancia-angular?si=7239e1942ff44e5981efd8576ec39ebf&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing accessed on February 24, 2024.

data sequences in order to acquire a response in sequence and to combine this with duration, scales recognize and a harmonic patch. In the TAI system, it is expected that the system can develop with the application of different sensors used in different places over the clarinet.

References

[1] Howard, K. (2022). Musical instruments as tangible cultural heritage and as/for intangible cultural heritage. *International Journal of Cultural Property*, *29*(1), 23-44. https://doi.org/10.1017/S0940739121000436

[2] Papadopoulos, G., & Wiggins, G. (1999). A*I Methods for Algorithmic Composition: A Survey, a Critical view and Future Prospects*.

[3] Caramiaux, B., & Donnarumma, M. (2021). Artificial Intelligence in Music and Performance: A Subjective Art-Research Inquiry. *Handbook of Artificial Intelligence for Music: Foundations, Advanced Approaches, and Developments for Creativity*, 75-95. https://doi.org/10.1007/978-3-030-72116-9_4

[4] Jankowska, L. (2023). Re-Thinking Virtuosity for the Hybrid Era of Multifarious Approaches. In *Contemporary Music Review* (Vol. 42, Issue 3, pp. 288–303). https://doi.org/10.1080/07494467.2023.2277544

[5] Crevoisier, A., & Polotti, P. (2005). Tangible acoustic interfaces and their applications for the design of new musical instruments. *Proceedings of the 2005 International Conference on New Instruments for Musical Expression (NIME-05), June*, 97-100. http://www.nime.org/proceedings/2005/nime2005_097.pdf

[6] Shanbaum, P. (2020). The Digital Interface and New Media Art Installations. In T*he Digital Interface and New Media Art Installations*. Routledge. https://doi.org/10.4324/9780429467899

[7] Manovich, L. (2022). *Lev Manovich: All Articles, 1992-2007*. https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:32016R0679&from=PT%0Ahttp://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012PC0011:pt:NOT

[8] Chou, T.-R., & Lo, J.-C. (2013). *Research on Tangible Acoustic Interface and Its Applications. Iccsee*, 913-916. https://doi.org/10.2991/iccsee.2013.230

[9] Travasso, R. (2023). The Clarinet as a Tangible Acoustic Interface: New Features. *The Barcelona Conference on Arts, Media & Culture 2023: Official Conference Proceedings*, 67-78. https://doi.org/https://doi.org/10.22492/issn.2435-9475.2023.6

[10] Travasso, R. (2024). The Clarinet as a Tangible Acoustic Interface. *International Journal of Social Science and Humanity*, *14*(1), 5-9. https://doi.org/10.18178/ijssh.2024.14.1.1185

[11] Magnusson, T. (2019). Sonic Writing, technologies of material, symbolic & signal inscriptions. In *Boomsbury Academic*. https://doi.org/10.1017/CBO9781107415324.004

[12] Kanga, Z. (2023). The Cyborg Hand: Gesture, Technology, Disability and Interdisciplinarity in Whatever Weighs

You Down. *Contemporary Music Review*, *42*(3), 319-338. https://doi.org/10.1080/07494467.2023.2279357

[13] Miranda, E. R. (Ed.). (2021). *Handbook of Artificial Intelligence for Music: Foundations, Advanced Approaches, and Developments for Creativity*. Springer. https://doi.org/10.1007/978-3-030-72116-9

[14] Zhang, Y., & Bucklew, M. (2023). *Max Markov Chain*.

[15] Daikoku, T. (2019). Tonality Tunes the Statistical Characteristics in Music: Computational Approaches on Statistical Learning. *Frontiers in Computational Neuroscience*, *13*(October), 1-12. https://doi.org/10.3389/fncom.2019.00070

[16] Kühl, N., Schemmer, M., Goutier, M., & Satzger, G. (2022). Artificial intelligence and machine learning. *Electronic Markets*, *32*(4), 2235-2244. https://doi.org/10.1007/s12525-022-00598-0

[17] Caramiaux, B., & Tanaka, A. (2013). Machine learning of musical gestures. *Proceedings of the International Conference on New Interfaces for Musical Expression*, 513-518.

[18] Agostini, A., & Ghisi, D. (2012). Bach: An environment for computer-aided composition in max. *ICMC 2012: Non-Cochlear Sound – Proceedings of the International Computer Music Conference 2012*, 373–378.

[19] Agostini, A., & Ghisi, D. (2015). A Max Library for Musical Notation and Computer-Aided Composition. *Computer Music Journal*, *39*(2), 11-27. https://doi.org/10.1162/COMJ_a_00296

[20] Louzeiro, P. (2018). Improving Sight-Reading Skills Through Dynamic Notation – the Case of Comprovisador. *Proceedings of the 4th International Conference on Technologies for Music Notation and Representation (TENOR'18), July*, 55-61. http://tenor-conference.org/proceedings/2018/08_Louzeiro_tenor18.pdf

Bio

Natural de Évora, Rui Travasso é licenciado em Clarinete, pós-graduado em performance clássica, mestre em ensino da música, e doutorado em Média-Arte Digital pela Universidade Aberta em associação com a Universidade do Algarve. Enquanto freelancer tocou com várias orquestras portuguesas e gravou álbuns com Primitive Reason, Quarteto Con´tradição, Mara, Catarina Pinho e Joana Amendoeira. Gravou ainda diversos álbuns a solo e, neste campo, destaca-se o seu álbum a solo Letters From Quarantine, editado pela Odradek Records em 2021. As suas obras estiveram em diversas exposições de onde se destaca a parceria com o Museu Zer0 no âmbito do projeto Magalhães. É membro da Orquestra do Algarve desde 2013 onde desempenha as funções de solista A e professor adjunto convidado do Instituto Politécnico de Beja. Rui Travasso é Artista Yamaha.

Luís Marques, natural de Évora, frequentou a Universidade de Évora onde se licenciou em Engenharia Informática. Trabalha como software developer desde 2008, sendo a sua especialidade liguagens .NET, e como database developer em bases de dados como MS-SQL ou OracleDB. No seu percurso como programador já participou em projetos na Suiça, Alemanha, França e Inglaterra. Em 2021 mudou para uma empresa de AI tendo participado em dois projetos: um chatBot e uma TimeSeries database. Como freelancer ajuda na criação de artefactos, tendo já participado em dois. In.S.Pitch para o MuseuZer0 e MAD Clarinet 2.1 na conferência internacional ARTeFACTo2022MACAO.

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