

Technology Set To Redefine Music

The collaboration of sensors and the internet will give wireless music a new meaning



The shutdown of public spaces due to the pandemic confined many people to their homes last year. This precautionary practice took a toll on some as they had to miss out on outdoor activities. Amidst all this, a new trend emerged. Individuals in Italy began playing music in their house balconies to entertain

and uplift each other during the bleak period. Such a gesture cemented the fact that music has the power to heal souls at difficult times.

Fast forward to 2021. After a year-long delay, the Euro 2020 football championship finally began. At the opening ceremony, members of the famous rock band U2 accompanied by DJ Martin Garrix gave a spectacular pre-recorded musical performance.

The above two scenarios are perhaps the perfect candidates where the Internet of Musical Things (IoMusT) could have been implemented. But what is IoMusT anyways? And what relevance it holds for the future of music, be it for concerts or group practice sessions? Let's find out.

Brief Intro To IoT

Before delving deep into the subject of IoMusT, let's get a short understanding of its parent, the Internet of Things (IoT). A wearable or a fitbit gathers physiological parameters such as body temperature, heart rate etc, and displays it. The smart device Alexa can control appliances like TV, air conditioner, refrigerator and more. These intelligent pieces of hardware are known as IoT devices. Here, embedded electronic sensors

gather data, transmit it to a remote server (known as ‘cloud’) and send back the processed results — all in a matter of a few seconds. Such device(s) with embedded sensors connect over an internet network to communicate with each other and offer the required services.

Think of it this way. While the “Internet of People” allows humans to connect and communicate with each other remotely, the Internet of Things helps machines to do the same (with other machines).

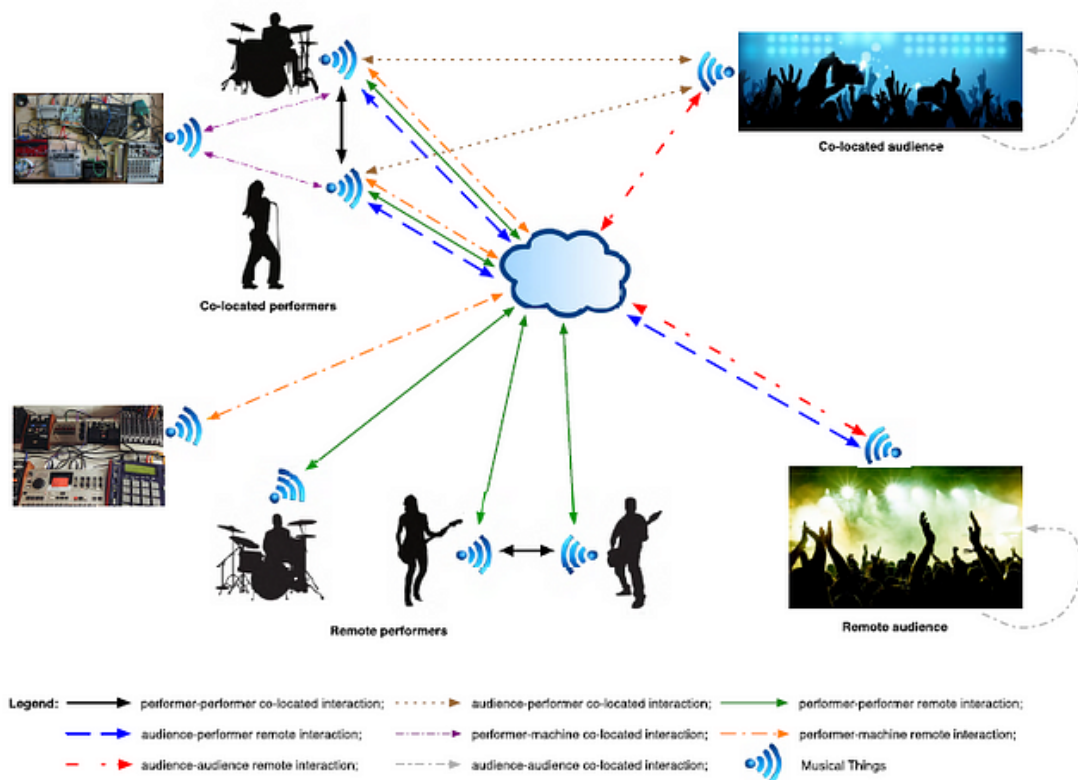
IoMusT: A Promising Technology

Instead of electronic appliances, IoMusT (also known as ubiquitous music or UbiMus) is concerned with musical instruments and associated hardware. It is an [emerging research field](#) that combines IoT, human-computer interaction and artificial intelligence to facilitate music production. The generated musical content is then transmitted to the cloud and received on musical things consisting of smart instruments, wearables or related analogue/digital hardware, both locally and remotely. This technology is beneficial for augmented concerts, remote rehearsals, smart music e-learning and smart studio production.

Here's further elaboration.

Musical Things: Musical things consist of smart musical instruments, musical haptic wearables, intelligent mixing consoles or speaker systems. They are interconnected musical devices that collect data using sensors, actuators and software.

Connectivity: Connectivity is about network infrastructure that supports multi-directional wireless communication between musical things in conjunction with relevant standards and protocols for a seamless real-time musical experience. Connectivity also entails interactive or non-interactive communication. For instance, IoMusT can allow music learners to obtain data analytics (regarding frequency, mistakes, pitch patterns under different environments) of their favourite music artists and learn from them. Also, rather than simply live-streaming a musical performance via Facebook or YouTube, musicians can connect their smart musical instruments to these social media platforms and share their music with a wide range of audience.



IoMusT ecosystem of interoperable devices connecting musicians with each other, as well as with audiences in co-located and remote settings. Credit: Luca Turchet et al

IoMusT aims to provide connectivity support across three broad categories: musician — musician, audience — musician and audience — audience. Cloud computing technologies can assist an internet-connected digital audio workstation (DAW) for smart musical instrument interaction.

For an audience to musician interaction, musical haptic wearables can leverage the sense of touch and feelings such as excitement or boredom of the audience for enriching the overall music performance, as well as provide creative participation.

Augmented Reality can take live concert performances to the next level by offering remote audiences the chance to experience an augmented stage and at the same time serve as an interactive space for both musicians and audience members. This can happen with AR/VR techniques superimposing a performance stage with a virtual environment and interactive elements.

Assumed Scenarios

Immersive Concert Experience: Arthur and James, two rock music fans, go to a concert venue to listen to their favourite band, who will be playing smart musical instruments. All audience members have been given electronic devices that will enhance their music experience. While Arthur selects a pair of smart glasses for viewing the instrument playing techniques, James goes for an armband that can detect the wearer's mood and thereby help the musicians decide their next track. Their friend Jenny, who couldn't attend the concert venue, gets to experience the live performance via a pair of VR headsets, giving her the feeling of being at the venue.

Remote Rehearsals: Amy (guitarist), John (singer), Samantha (bassist) and Harry (drummer) have an upcoming music contest for which they need to rehearse. Unfortunately, due to the large travel distance, they are not able to meet at a common place. Thankfully, with the power of IoMusT, they all can remotely practice together by connecting their smart musical instruments online. This facilitates John in a big way to synchronise with the music while singing.

Music e-Learning: Tanya is learning how to play the guitar. She connects her musical instrument with an app via Bluetooth. Based on her playing style, the app gives her helpful practice suggestions. Even her progress data gets stored in the app's cloud service, which is sent to her guitar teacher for any further improvements.

Smart Studio Production: Anthony, a recording engineer, is producing a music album based on the live performance of a popular music band. He is aware that recording music within the silent confines of a studio is quite challenging from recording under an open atmosphere. Thankfully, he captured the sounds of each smart musical instrument played in the live

performance by connecting his smart mixing console to them. Now he has to creatively mix them and upload them to the cloud so that they can be reviewed by others before being released.

Challenges & Solutions

Latency: It is arguably the biggest inhibitor of IoMusT. Unlike playing music on the spot, where two or more musicians can coordinate amongst themselves quickly, any latency or delay over the internet (due to varying network strength) makes real-time music synchronisation much harder. A delay of milliseconds can lead to uncalled errors. 10–60 ms can be considered acceptable. But 65 ms and beyond can cause synchronisation problems.

Need for more R&D: As of now, the research on IoMusT is fragmented. Existing wireless protocols of IoT are unsuitable for the ultra-low latency required for the wireless interconnection of musical instruments. Although 5G aims to offer a very high data rate thanks to the usage of [millimetre waves](#) (mmwaves), latencies will render them insufficient. For reliable communication, [edge computing](#) is a much better alternative to cloud

computing as the majority of the processing takes at the edge of the network (i.e. where the data is produced rather than a separate server).

This drastically reduces latency as there is no requirement for transmission.

Interoperability & Standardisation: There is a need to optimise existing wireless protocols such as Wi-Fi, Bluetooth or 5G for supporting the MIDI or OSC standard actively used by the musical industry.

Musical Things Design: Current design techniques do not adequately support widescale musical interactions. Wearable systems that can convert multiple sensory modalities are needed for active audience participation in live music performances. The possibilities with VR have also not been explored completely yet. Once again, an in-depth research is required.

Pedagogical: Although there are a few innovative music teaching solutions out there promoting remote learning, they are low in numbers. With the advent of IoMusT, these along with several other methodologies

need to be brought in to make music learning/teaching more exciting (and less of a chore).

Security/Legal: Wireless connectivity does have its benefits. However, there is an inherent risk of data leakage. On top of that, if there aren't strong governing laws in place for preventing privacy infringement, then IoMusT can become a breeding ground for music piracy. To prevent this, algorithms relating to encryption should become even stronger.

Future Looks Good

Be it consumer or industrial applications, IoT technology is revolutionising our world and helping us execute our daily tasks effortlessly. In conclusion, IoT will surely usher in a unique way of experiencing music via IoMusT. Yes, like every emerging technology, IoMusT will have to face many challenges. But they will reduce with time once IoMusT securely establishes itself. And if a similar lockdown situation in the future forces us to abandon all forms of outdoor entertainment, at least we wouldn't have to worry about stopping the music.

