Politecnico di Torino

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ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

Remote musical education of disabled students

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Context of the research activity	Research actitivites in the field of Networked Music Performance (i.e., synchronous musical interactions between performers in different geographical locations, supported by ultralow-latency audio/video streaming), focused on the integration of motion tracking and haptic feedback technologies in NMP frameworks to enable fruition by subjects with motor/auditory/visual impairments.
	The final goal is to make real-time remote music interactions (Network Music Performance - NMP) a reality, by enabling web-mediated music teaching and collaborative activities of musicians from distant locations. The main focus is on the one hand on latency minimization to ensure real time interaction with a quality similar to the one of in presence ensemble music, on the other hand on the adoption of Artificial Intelligence (AI)-based technologies to guarantee accessibility to remote interactive musical sessions by subjects with limited mobility and/or visual/auditory impairments, paving the way towards inclusive technology-enhanced pedagogical approaches. More in detail, motion tracking systems and haptic devices will be leveraged to create Virtual Reality (VR) or Augmented Reality (AR) performative

Objectives	environments. Gestural data acquired via motion tracking technologies will be either visualized via avatars, or locally converted into haptic feedbacks via dedicated actuators to convey to the user information regarding the gestures performed by the remote counterpart, with the aim of complementing visual and/or auditory perception, or to control smart musical instruments. Tactile surfaces will be leveraged to amplify vibrations generated by soundwaves locally reproduced during the playout of the streamed audio contents, thanks to audio processing techniques. Tactile actuators will be also used to replace auditory cues (e.g., the metronome beat) when needed. All the above mentioned disability-friendly functionalities will be integrated In a dedicated hardware (music box) specifically designed for ultralow-latency streaming and processing of audio/video and motion signals. Moreover, AI will be leveraged to achieve a flexible and optimized design of the network backend portion, to support a scalable deployment of the communication infrastructure, based on a client-server service paradigm with remote audio/video synchronization, mixing and broadcasting functionalities to external audience, with the final goal of latency minimization. Optimization methods from the field of operations research will permit to automate and optimize the deployment of Virtual Machines (VMs) hosting dedicated mixing/streaming servers, possibly located in Edge Computing (EC) nodes available in the proximities of the users involved in the NMP session. Moreover, Machine Learning (ML)-based traffic prediction methods will be leveraged to dynamically adapt audio/video streaming parameters to the evolving network load conditions. ML algorithms will also be adopted to perform audio packet loss concealment and thus mitigate the impact of late/missing packets due to network congestion on the perceived quality of the audio signal. After validating the integration of the accessible frontend with the backend portion in a laboratory environment, the framework and its functionalities will be field-tested involving professional music teachers and students performing from different geographical locations.

Skills and competencies for the development of the activity	Advanced programming skills in C/C++, Java, Python. Knowledge in audio processing techniques, data mining techniques and machine learning is preferential.