# A Fully-Immersive Hapto-Audio-Visual Framework for Remote Touch

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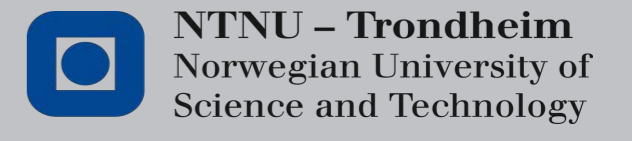
## INTRODUCTION

Nowadays, different commercial off-the-shelf (COTS) haptic feedback devices exist. However, most of the currently available devices are still quite expensive. Besides, the majority of these devices are based on proprietary hardware and software. Even though different haptic software libraries are available, the integration of these devices still requires significant programming skills [1]. In addition, most of the currently available libraries do not offer flexible tools for modelling, simulation and analysis. Consequently, researchers are forced to develop custom-made solutions that often suffer from a lack of generality.

In order to allow researchers to add haptic capabilities to their applications in a more flexible, interactive and transparent fashion, an open-source, low-cost framework for a fully-immersive haptic, audio and visual experience is proposed in this work. The framework allows for the flexible, interactive and seamless addition of haptic capabilities to applications. The underlying idea is shown in Fig. 1. The proposed framework allows for the creation of a truly immersive user experience. A real-time one-to-one correspondence between the real and the virtual world can be transparently created. As such, a variety of industry and research applications are made possible. For instance, this technology may be adopted in the contest of Smart Cities to enhance the interface between nature and culture by stimulating the senses or as a complement to the landscape [2].



Fig. 1. The concept for developing an open-source low-cost framework for a fully-immersive haptic, audio and visual experience (e.g. user playing the piano).

## FRAMEWORK ARCHITECTURE AND CASE STUDY

The framework architecture is shown in Fig. 2. This framework is realised by exclusively adopting commercial off-the-shelf (COTS) components and tools. In particular, vibration actuators and open-source electronics are employed in the design of a pair of novel and inexpensive haptic gloves. These gloves, shown in Fig. 3, allow for establishing a kinesthetic link between a human operator interacting
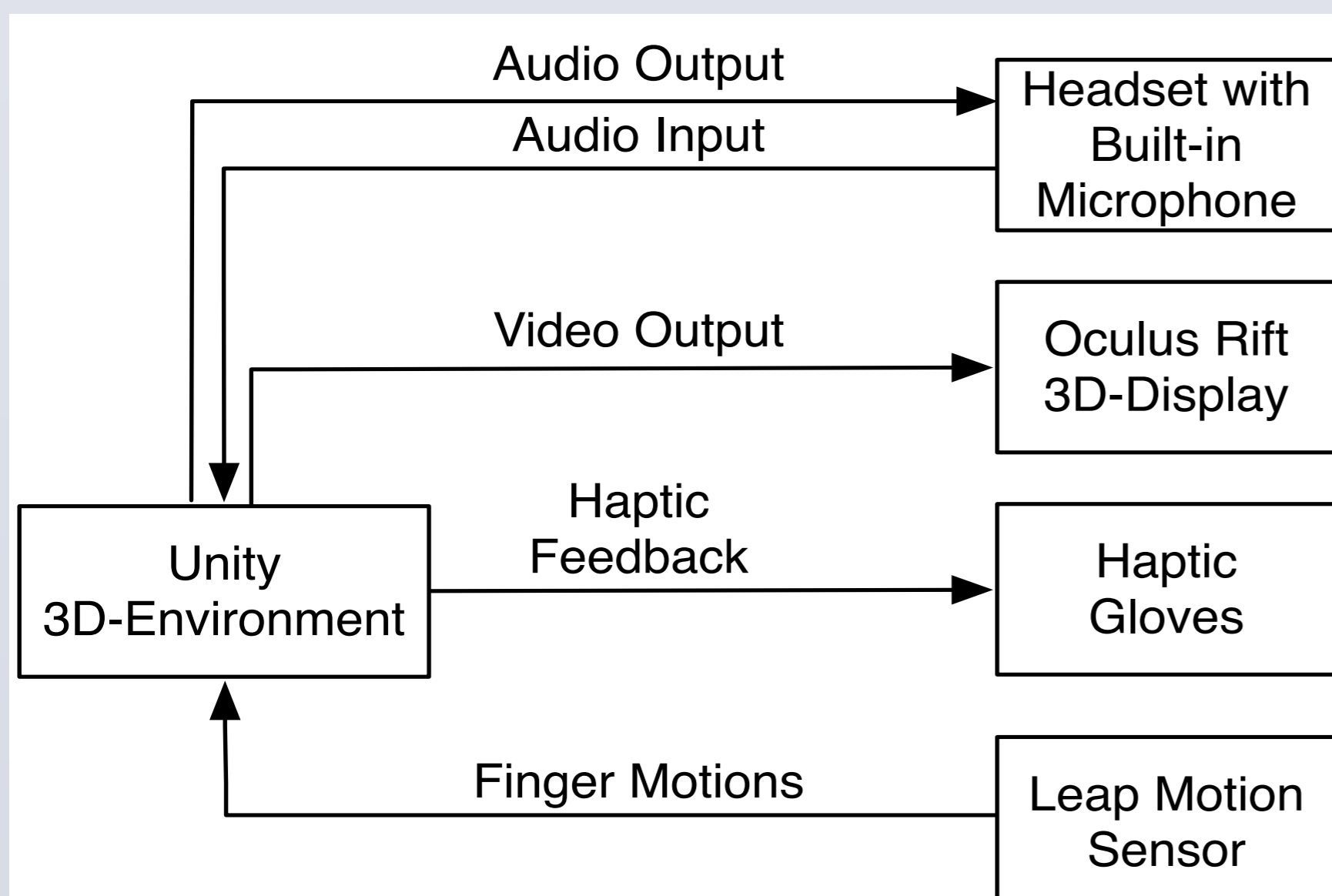


Fig. 2. The proposed framework architecture.



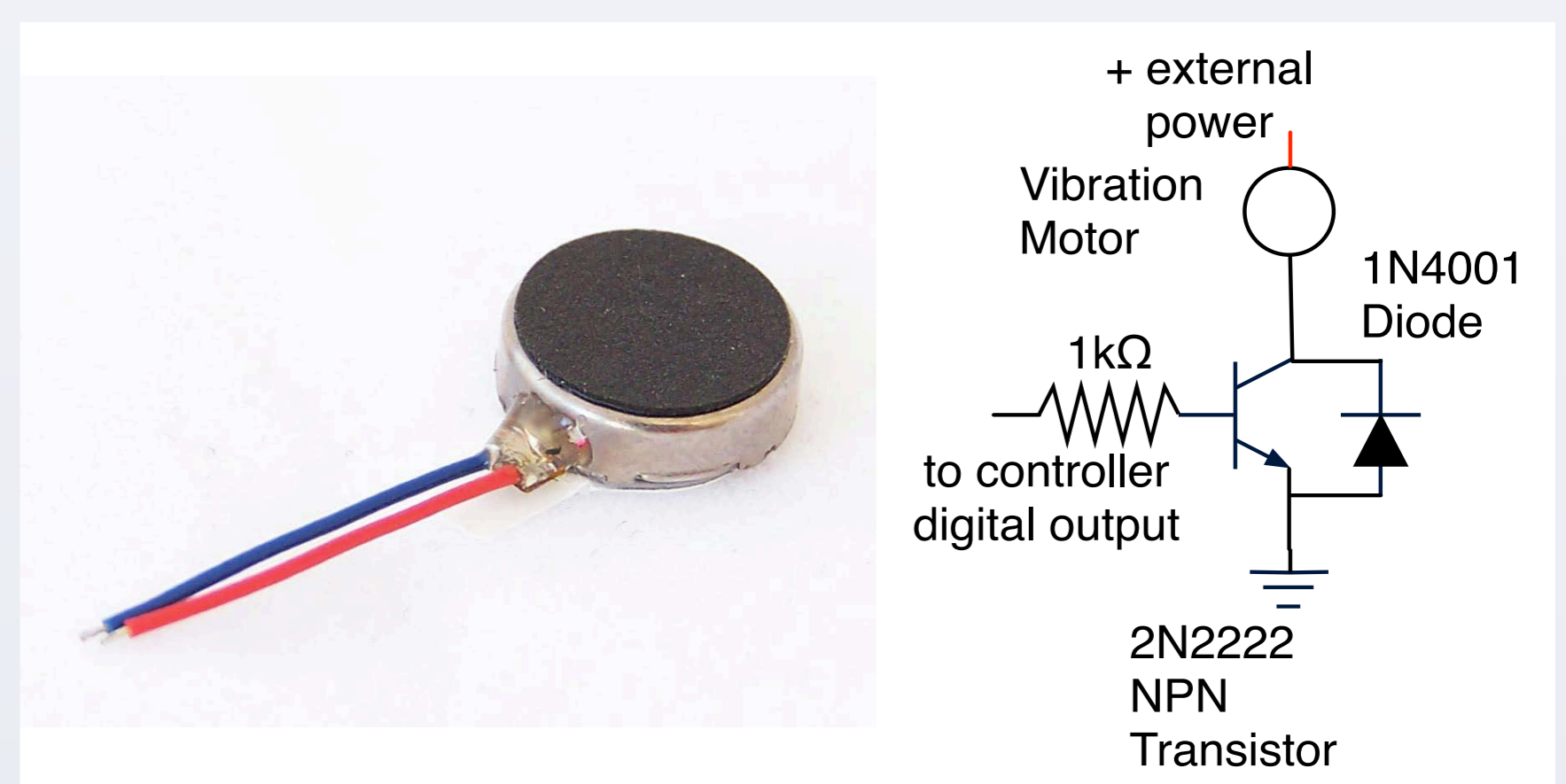Fig. 3. The proposed low-cost haptic gloves.



Fig. 4. One of the embedded vibration actuators and the corresponding control circuit.

with a computer-generated environment. One of the embedded vibration actuators and the corresponding control circuit is shown in Fig. 4. This circuit consists of a 1KΩ resistor, a 1N4001 diode and a 2N2222 NPN transistor.

To demonstrate the potential of the proposed framework, a case study is studied. In particular, a virtual scene in which the user can play the piano is developed. The experiment setup is shown in Fig. 1. Once collisions between the user's virtual fingertips and the piano keys are detected, the corresponding vibration motors on the gloves are actuated. A demo video is available on-line at http://youtu.be/ywCmqn_SuDo. By implementing a network connection between two instances of the proposed framework, a piano player can remotely teach another player by transmitting the tactile interaction. This same application can be extended to a possible scenario for a remote tactile interaction.

## CONCLUSIONS

The proposed framework enables researchers to easily add haptic capability to their systems. Different functionalities can be achieved including tracking the operator's hand and finger motions, detecting collisions between the operator's virtual fingers and the virtual objects, computing reaction forces in response to contacts and motion, and exerting an intuitive force feedback. A variety of local and remote applications are therefore possible. In the context of Smart Cities, this technology may be adopted to enhance the interface between nature and culture by stimulating the senses or as a complement to the landscape [2]. This approach may contribute to create a communicative macro-environment that has the characteristic to propose an expanded, increased, hybrid and ubiquitous space to go through and to live in more of a haptic way that optical [3].

## REFERENCES

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