# *Twech*: A Mobile Platform to Search and Share Visuo-tactile Experiences

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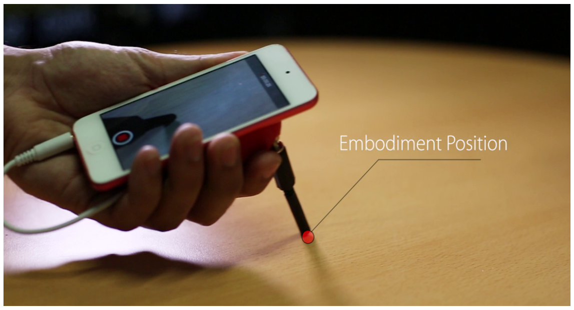
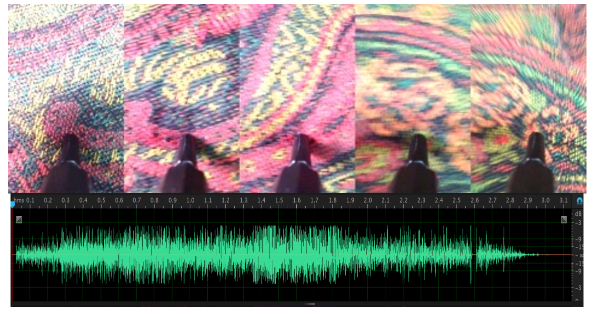



(a) Recording contacted textures using an embodied probe



(b) Captured video image: the probe data is seen at the bottom of the image

**Figure 1:** *Twech* is at once an attachment for capturing tactile experiences and a device for playing back haptic experience. As shown in (a), the device attaches to a smartphone. To record a visual and tactile experience, the user attaches the device through the smartphone's audio jack. The user can then record a visual and tactile experience by simultaneously capturing the haptic data and using the phone to record a video, as shown in (b). The headphone jack is used both as a microphone and an earphone jack. Therefore, in order to re-experience the haptic recording, the user uses the same configuration. The haptic actuator in the back of the device responds to the haptic-vibration data transferred via the headphone jack.

## 1. Introduction

When using social networking, users often upload digital media to capture their experiences, and this includes video or photos of meals, landscapes, gatherings of friends, etc. These events are captured with a camera, recorded by a microphone, or archived using a video camera. Such media provides us with visual, audible, or integrated audio-visual experiences. However, up until now, sharing one's corresponding haptic experiences has not been possible. If this haptic experience can be shared, the sensory feedback will be sufficiently compelling and easy to understand in order for a more complete experience from a first-person perspective.

The TECHTILE toolkit [Minamizawa et al. 2012] is an easy-to-use device that can record and playback realistic haptic experiences. This device captures solid-borne sound waves resulting from friction-evoked sounds using a microphone. As a haptic feedback actuator. Because recorded audio signals are associated with haptic events, users can enjoy high-fidelity haptic experiences using this device.

In this work, we propose a mobile platform, called *Twech*, which enables users to collect and share visuo-tactile experiences. This platform can also discover materials that can provide a similar haptic feeling. Users can record and share visuo-tactile experiences by using a visuo-tactile recording and displaying it through an attachment to a smartphone. The proposed system allows users to share their experiences instantly over social media, and to re-experience shared data such embodiment visualization.

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Further, *Twech*'s search engine queries similar experiences—the texture of a scratched surface or an animal's fur, for example—and these can be shared with others. Tactile data is analyzed using a deep-learning algorithm that is expanded in order to recognize tactile materials. Thus, were this engine included in an online shopping store, for instance, users could find clothes with a particular feel to the fabric based on an analysis of the recorded signals, as shown Figure 2. In other words, users could search for tactile data through textures, rather than explicit verbal expressions.

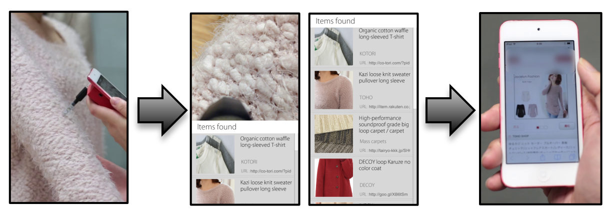

**Figure 2:** *Example scene of online shopping*

## 2. Related Work

For both digital information and the real world, EyeRing [Nanayakkara et al. 2013]. EyeRing is a device attached to the user's finger for capturing color, words, and views of real objects uses an actual index finger to the embodiment position. FingerReader [Shilkrot, et al. 2015] is a similar device that is able to recognize where a user points in real-time. FingerReader facilitates expanded embodiment with increased target contacts.

TouchCast [Takeuchi et al. 2012] was proposed as a vibro-tactile search engine based on voice recognition using the Earth Mover's Distance and Mel-Frequency Cepstrum Coefficients. This method is common in the field of image recognition for solving invariances. The first convolutional neural network proposed was called LeNet [LeCun et al. 1989]. Subsequently, AlexNet [Krizhevsky et al. 2012] was proposed. AlexNet was developed in ILSVRC2012, and has since become one of the most popular convolutional neural networks. Unlike LeNet, AlexNet offers high performance for recognizing images. In this paper, we adopt AlexNet to develop a search engine for vibro-tactile signals.

## 3. System Description

We propose a mobile platform that is able to provide four features of a haptic experience. The proposed system uses visual and tactile feedback for displaying a recorded experience.

- Visual feedback from recorded video.
- Tactile feedback from recorded tactile signals.
- Enhanced visual feedback using tactile signals.
- Enhanced tactile feedback using pseudo-haptic feedback.

*Twech* consists of two components: one component captures video and audio signals that are associated with tactile experiences; the other provides a haptic experience that is similar to the recorded signals. We discuss how these captured images are analyzed with our system.

### 3.1. Attachment for Record and Display

We developed a smartphone attachment for sharing visual and tactile experiences [Nakamura et al. 2015]. As shown in Figure 3, the device consists of a tactile amplifier (AMP15W-8006), a microphone (PRIMO MX-M4758) that is able to capture frequencies as low as approximately 10 Hz, a voltage divider, and a haptic actuator (Tactile Lab Haptuator Mark-II). The actuator is strong enough to provide haptic feedback with the entire smartphone device. This configuration is also effective at making users aware that they are in contact with an object. The microphone, which is embedded in the contact probe, helps users to focus on the contact point between the probe and the materials. The captured data is recorded as an audio signal. This audio signal is converted into tactile signals with Haptuator. To re-experience the sensations recorded by users, the haptuator uses visuo-motor coupling and accordingly plays back the recorded tactile data. Our previous research showed that this haptic feedback system provided sufficient information to re-experience a scene with the motion of swinging a badminton racket [Mizushina et al. 2013]. The proposed device is intended to offer an alternative method for sharing embodied experiences recorded by another person.

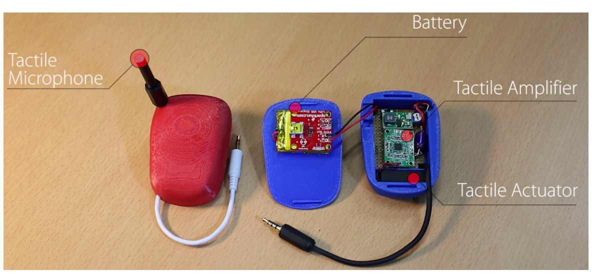


**Figure 3:** Attachment overview: microphone includes an embodied probe; captured signals convey audio through a jack attached to the smartphone; the vibro-tactile wave is displayed using a tactile actuator though a tactile amplifier from the smartphone.

### 3.2. Haptic search engine

To build the haptic search system, we developed an algorithm that finds tactile data that is similar to the target data. We employed a convolutional neural-network algorithm for tactile recognition [Krizhevsky et al. 2012](Figure 4). This architecture is capable of learning scale and translational invariances. For example, the scale invariance of tactile data is equivalent to the amplitude of an audio signal. Translational invariance is associated with a frequency shift that is caused by the difference in touching speed. These invariances successfully analyze our collected dataset. For example, the system can classify how users touch an object, whether at slow or fast speeds. The input data is also analyzed using a spectrogram, and the data is divided into low-frequency (0 Hz – 1000 Hz) and high-frequency (1000 Hz – 20 kHz) components. The final output of the analyzed data is shown in Figure 5, showing how collected signals are successfully classified into a limited number of categories. This network recognizes search results that are based on the vibro-tactile map. When network acquires new material, our developed recognition system is capable of calculating the similarity of new inputs to known materials. The materials in the area have a rough texture (e.g., a washboard, shell, or a LEGO block). By contrast, the materials in area have a smooth texture (e.g., textiles).

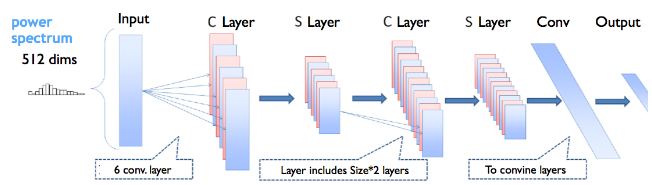


**Figure 4:** Machine learning for dual-layered tactile recognition: convolution layer and a subsampling layer for the neural network [Krizhevsky et al. 2012].

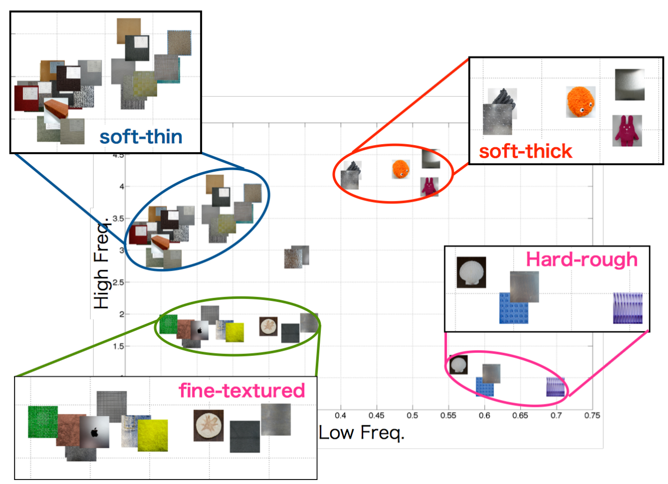


**Figure 5:** Tactile map showing 46 material thumbnails. The tactile wave uses a dataset comprising 460 items for capturing items touched at slow or fast speeds. In this map, materials are separated into four clusters: soft-thin (e.g., cloth); soft–thick (e.g., a soft toy), fine-textured (e.g., a shell); hard-rough (e.g., a LEGO block).

## 4. Possible User Experience

*Twech* is a mobile platform that enables users to share visuo-tactile experiences and search other experiences for tactile data. User can record and share subjective experiences using the visuo-tactile information recorded and presented with the proposed smartphone attachment. This setup allows the user to share and re-experience shared data over social media.

Further, *Twech*'s search engine locates similar visuo-tactile experiences—for instance, the texture from a scratched surface or the fur of an animal—from collected tactile data. The similarity is automatically calculated by using the proposed search engine, which is based on deep learning. *Twech* allows users to share and find haptic experiences from visual-tactile data uploaded to a cloud server, as shown in Figure 6. In addition, the proposed system provides a platform for sharing the experience of interacting with pets. The recorded data is utilized for recording an enhanced interaction with a pet to facilitate visuo-audio-haptic feedback. Users who are not in a position to touch the animals have an interactive experience with them, as depicted in Figure 7.

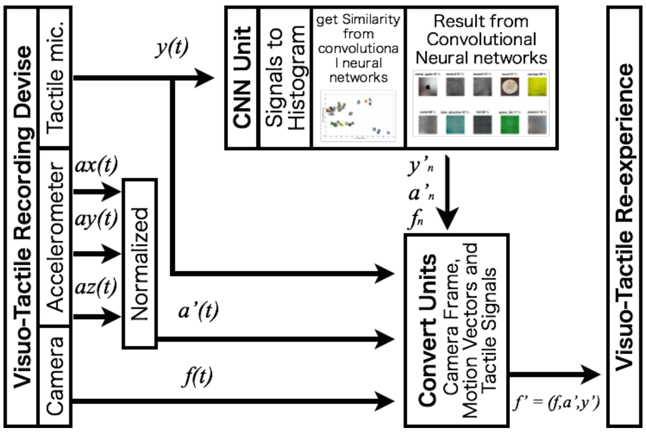


**Figure 6**: Proposed architecture for displaying recorded data and recognizing vibro-tactile waves. In this case, we used a convolutional neural network.

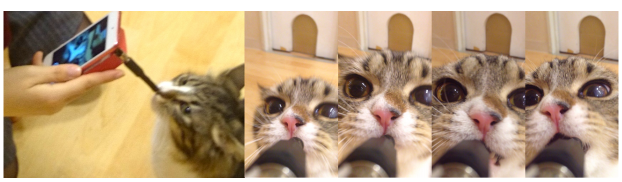

**Figure 7:** Case experience: recording interactions with a cat.

## 5. Future direction

In this paper, we proposed a mobile platform, called *Twech*, which enables users to collect and share visuo-tactile experiences. The proposed system includes an attachment. The attachment enables users to re-experience a recorded experience. The haptic search engine was based on a convolutional neural network—a popular deep-learning algorithm for recognizing images. We applied this algorithm for recognizing tactile signals.

In future research, we design an embodiment visualization for capturing tactile data and for displaying the recorded data to users who do not have the proposed device. In addition, we shall propose a tactile data format for the search engine,

## 6. Acknowledgements

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## References

K. Minamizawa, Y. Kakehi, M. Nakatani, S. Mihara and S. Tachi. 2012. TECHTILE toolkit: a prototyping tool for design and education of haptic media. In *Proceedings of the 2012 Virtual Reality International Conference*, Article 26, 2p.

A. Hettiarachchi, S. C. Nanayakkara, K. P. Yeo, R. Shilkrot and P. Maes. FingerDraw: More than a Digital Paintbrush, *ACM SIGCHI Augmented Human*, 4p.

Y. Takeuchi, H. Katakura, S. Kamuro, K. Minamizawa and S. Tachi. TouchCast: an on-line platform for creation and sharing of tactile content based on tactile copy & paste. In *Adjunct proceedings of the 25th annual ACM symposium on User interface software and technology,* 13-14, 2p.

Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner. Gradient-based learning applied to document recognition. *Proceedings of the IEEE 1998*, 2278-2324, 46p

A. Krizhevsky, I. Sutskever and G. Hinton. 2012. Imagenet classification with deep convolutional neural networks, In *Advances in Neural Information Processing Systems*, vol. 25, pp. 1106-1114, 8p.

S. Nanayakkara, R. Shilkrot, K. Peen Yeo and P. Maes, EyeRing: A Finger Worn Input Device for Seamless Interactions with our Surroundings, *In the proceedings of the 4th International Conference on AugmentedHuman*, 7p.

H. Nakamura, N. Hanamitsu and K. Minamizawa. 2015. A(touch)ment: a smartphone extension for instantly sharing visual and tactile experience. In *Proceedings of the 6th Augmented Human International Conference*, 223-224, 1p.

Y. Mizushina, W. Fujimura, T. Sudou, C. L. Fernando, K. Minamizawa and S. Tachi. 2015. Interactive instant replay: sharing sports experience using 360-degrees spherical images and haptic sensation based on the coupled body motion. In *Proceedings of the 6th Augmented Human International Conference*, pp. 227-228, 2p

K. J. Kuchenbecker, J. Romano and W. McMahan. 2011. Haptography: Capturing and recreating the rich feel of real surfaces. In *Robotics Research*, pp. 245-260, 5p.