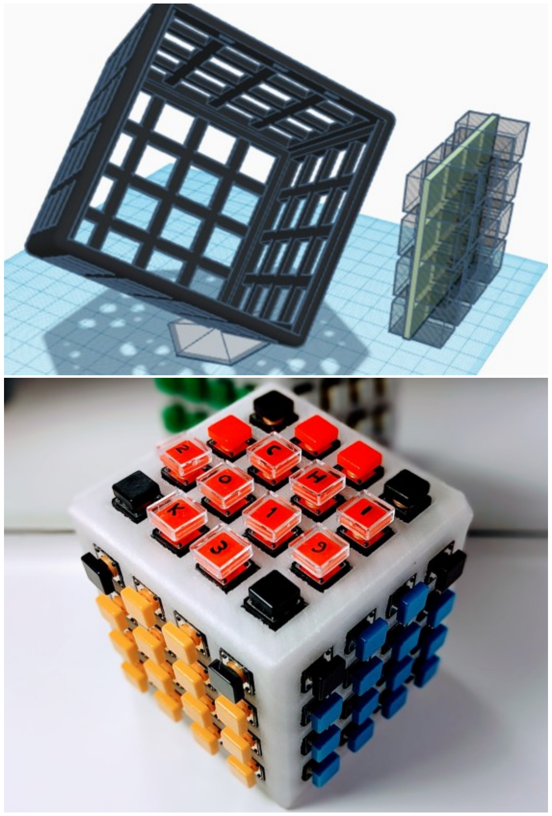

Figure 1: From top to down (Keycube 3D model and real prototype).

Keycube is a Kind of Keyboard (k^3)

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ABSTRACT

Alternate realities through headsets, such as augmented, mixed and virtual reality are becoming part of people's everyday life. Except in some limited context, usual keyboards are inappropriate for such technological medium and alternative interfaces for text-entry must be explored. In this paper we present the keycube, a general-purpose cubic handheld device that goes beyond the text-entry interface by including multiple keys, a touch-screen, an inertial unit with six degrees-of-freedom and a vibrotactile feedback. Strong of its form factor and affordance, the keycube offers advantages with regards to mobility, comfort, learnability, privacy and playfulness. Thus, the combination creates a novel text-entry interface convenient for many use cases across the whole reality-virtuality continuum.

KEYWORDS

Interactive device; text-entry; mixed reality; virtual reality; cube; keyboard

CHI'19 Extended Abstracts, May 4-9, 2019, Glasgow, Scotland, UK.

ACM ISBN 978-1-4503-5971-9/19/05.
https://doi.org/10.1145/3290607.3313258

Figure 2: Transparent key cover with "character" inscription.

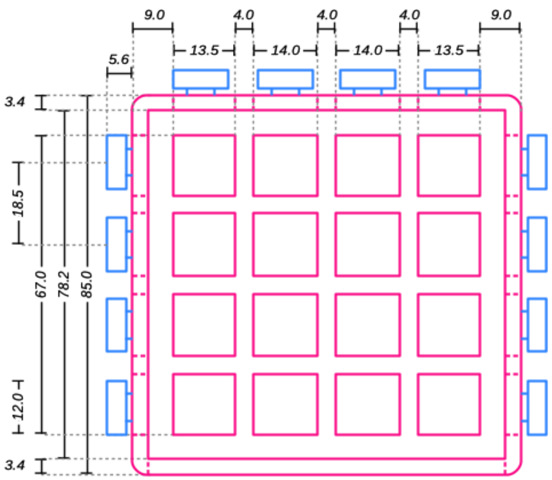

Figure 3: Prototype size.

Figure 4: "Diagonal" position

1 INTRODUCTION

With the increasing use of augmented, mixed and virtual reality headset, their contexts of use are widening and becoming more heterogeneous. The need of text-entry interaction remains largely ubiquitous for many use cases. The physical keyboard has been exploited for such technological medium [2] but is limited to a few contexts where the user is mainly immobile and seated. Many text-entry interactions are explored or used in commercial headsets (e.g. Microsoft HoloLens), such as virtual mid-air keyboard, voice-to-text and others dedicated wearable devices such as gloves [8]. In this paper, we introduce the keycube concept and our prototype (Figure 1) which is a wireless tangible cubic device dedicated to text-entry input. Our keycube features include (i) 80 keys, (ii) a touchscreen, (iii) an inertial unit with six degrees of freedom (DoF) and (iv) a haptic/vibrating motor.

The primary contributions of this work are (i) the keycube concept, design and prototype which aim to unify text-entry interaction for multiple contexts of use across the whole reality-virtuality continuum [5] and (ii) a demonstration of the keycube with an interactive text-entry speed game.

2 RELATED WORK

Since Sheridan *et al.* [7] explored and showed natural affordance of the cube, many works have investigated a large variety of cubic shape to create input and output devices. Lefeuvre *et al.* [4] found nine recurring design properties dedicated to the cubic shape among forty-one works in the literature. "*Manipulation as Input*" property is one of them, in particular for a three-dimensional (3D) space interaction such as the Cubic Mouse [1] or the Rubikon [6] that allow intuitive control of the X, Y, and Z axes. Other works, the Loaded Dice [3] and Fidget Cube [9] share the "*Multifunctionality*" property by providing different interactive features for each of their faces.

Despite the popularity of this platonic solid, we believe the cubic shape has not been fully exploited and there is still room to explore it, for instance as a text-entry input device where mixed and virtual reality experience could benefit high mobility coupled with fast typing and 3D control.

3 KEYCUBE

The keycube is a new kind of tangible device dedicated to text-entry, in a sense similar to a keyboard but in a cubic shape, small enough to be covered and held with hands. Multiple key matrices are disposed over the faces of the cube. The keycube form factor allows the device to be highly mobile without reducing the comfort, the key size and the numbers of fingers involved with a typical keyboard.

3.1 Current Prototype

With these design considerations in mind, we chose to cover five faces with 4x4 matrix keys, for a total of 80 keys, in order to offer the same flexibility than a typical keyboard and avoid chording technique. The keys have face-distributed color caps (red, green, blue, yellow, white and black for the top corner) to help the 3D representation and manipulation.

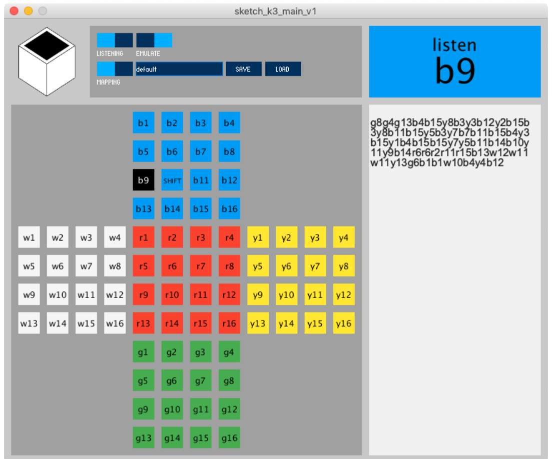

Figure 5: Keycube software including interactive layout, mapping and emulation.

Figure 6: Mixed reality use case.

The key size (12x12mm) and space between their centered pivot (18.5 mm) are similar to the one found on a typical keyboard. Transparent key covers with inscriptions are movable among the keys in order to physically customize the keycube layout (Figure 2). The covers are optional visual helpers.

The only face without keys is flat and includes an embedded power switch, a touchscreen (2.8 inches) and is convenient to put down the device. The prototype also includes a 6-DoF inertial unit (gyroscope and accelerometer) and a wireless communication module (Bluetooth), all controlled by an Atmel ATmega2560 powered by a 9v battery. Our current prototype can also be wired and thus powered and communicate through USB cable. The 3D printed body structure size (without the keys) is 85.0 * 85.0 * 85.0 mm (Figure 3), the overall size is 96.2 * 96.2 * 90.6 mm (l*W*H) and weight around 430 gr (battery included). A preliminary user study with 31 participants showed that the current size is right enough to be grasp and handled properly, in particular with the preferred diagonal position (Figure 4). However, the actual prototype felt slightly too heavy.

3.2 Software

An accompanied tool (Figure 5) has been developed with the Processing software sketchbook [10]. The tool allows the users (i) to emulate text-entry to the system, (ii) to customize the key layout by mapping characters to different keys, (iii) to save and load custom key layout, (iv) to see an interactive key layout showing the current state of each key and (v) to have a keycube viewer on top of other apps. The viewer is an optional visual helper that has the benefit to be spatially out of the physical device. The viewer is an important feature regarding the user learning curve of the keycube.

4 APPLICATIONS

The keycube is a general-purpose handheld device that goes beyond the text-entry interfaces by including a touchscreen, an inertial unit and a haptic (vibrating) feedback. This combination creates a novel interactive space ideal for controlling any realities such as augmented, mixed and virtual (Figure 6 and 7). The keycube mobility property allows the user to enter text and control their experience while moving. The keycube can be held or easily hang from the wrist or neck. Thus, the device is well suited for any generic text-entry tasks as much as design tasks thanks to the inertial unit (6-DoF), the touchscreen and the vibrotactile feedback that have all been explored and shown to be relevant in three-dimensional manipulation. For instance, we could envision a case where users fully exploit the keycube by writing and programming in a new kind of 3D integrated development environment (IDE) either in mixed or virtual reality.

Finally, the keycube could be used for as many cases in the real environment, connected to a computer to replace a keyboard on the desk or even connected to a tablet. Due to its form factor, the keycube can be used with a lot of different arms and body postures, thus lying in a sofa (Figure 8) or in a bed with the device connected to a TV. Tangible devices are prone to be shared, the keycube is no exception and could be shared with friends or colleagues in a meeting room. The keycube could also initiate some entertaining challenge similar to the Speedcubing [11] where people try to resolve twisty puzzles as quick as possible.

Figure 7: Virtual Reality use case.

Figure 8: Real environment (Sofa)

5 CONCLUSIONS

In this paper, we presented the novel concept of the keycube, our initial design direction and prototype. The keycube is a generic handheld cubic text-entry device that includes multiple keys, a touchscreen, an inertial unit and a vibrating motor. We believe the keycube has the potential to be used for a very wide variety of experiences across the whole reality-virtuality continuum, and we hope others will build upon our design to improve the interactive space offered by this device.

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