qVRty: Virtual Keyboard with a Haptic, Real-World Representation

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Abstract. Virtual Reality systems offer great possibilities to analyze and interact with data. However, they still lack a commonly accepted, efficient text input technique that allows users to record their findings. To provide users with an efficient technique for text input, a real keyboard and the user's hands are transferred into the virtual world. This allows real haptic feedback of the device and, as a user study shows, results in fast and accurate text writing. The proposed approach shows that a real-world ability can be transmitted directly into the virtual world without much loss.

1 Introduction

Virtual Reality (VR) allows users to interact with complex virtual worlds using buttons, gestures or gaze. This allows them to analyze data or explore virtual worlds. However, it is also necessary to input text, add annotations or log results. To implement a efficient text input technique that is fast, little error-prone and easy to learn, the well established QWERTY keyboard is suitable as a basis. Yet, to supply users with the full control over the keyboard, visual and haptic feedback is needed. Ideally, users can switch from the desktop pc into the virtual world without experiencing any performance loss, taking their writing skill with them.

2 Related Work

Current work can be grouped into device-based, gesture-based or multimodal input techniques [17]. Device-based techniques use a game controller [11, 24, 32, 27, 14, 6, 33], phone [7, 13], keyboard [18, 12, 3, 7, 19, 31], pen and tablet [25, 3, 7] or touch [16, 8, 4]. Gesture-based methods use hand [2, 3, 7, 26, 1, 23, 9, 5] and head gestures [34]. Multimodal techniques often use speech [22, 10, 3].

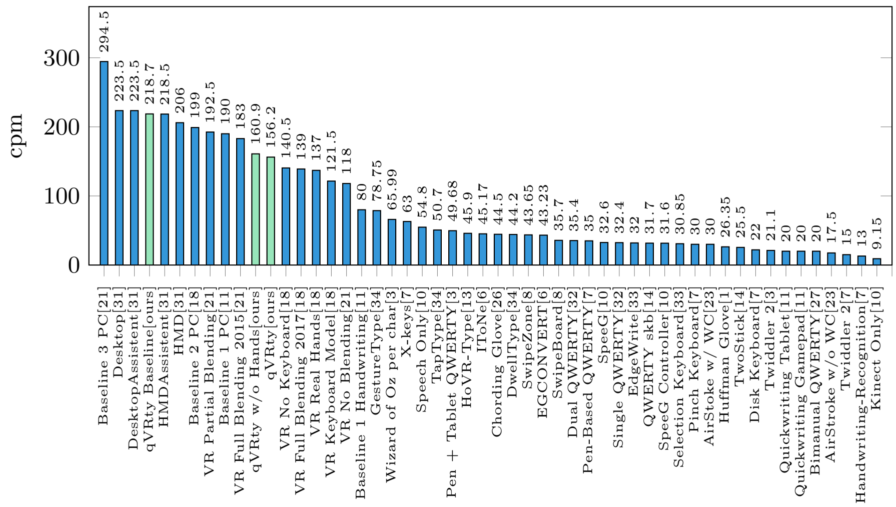

Fig. 1. Input speed of different techniques in characters per minute (cpm).

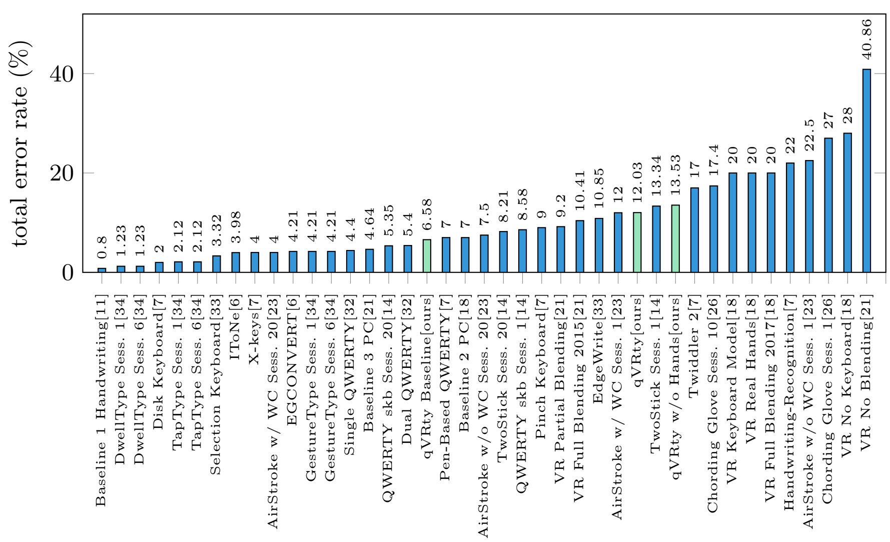

Fig. 2. Total error rate [28, 29] of different techniques in percent. If the total error rate is not available the corrected error rate is used, since it is an estimation downward.

3 Text Input with a Haptic, Real-World Keyboard

Although there are plenty of methods that achieve text input in Virtual Reality, no technique has established itself as the defining standard. An analysis shows that the fastest techniques use a QWERTY keyboard (see Fig. 1). Error rates are lower when users type slower and concentrate on inputting single characters or when word correction is used (see Fig. 2). Haptic feedback improves input performance and usability [20, 15, 30].

We therefore present *qVRty*: a virtual keyboard with a haptic, real-world representation (see Fig. 3). Furthermore the hands of the user are tracked using a Leap Motion and then displayed in VR. The real keyboard is tracked using the Vive Lighthouse system and its virtual counterpart is placed at the exact same location in the VR world. The location of the Leap Motion device is tracked the same way. Since the keyboard is wireless it can be carried around the room and set up everywhere. However, the hand tracking solution is still cable bound and does not allow this. Adjustments to the virtual keyboard contain a larger font size and a red highlight on button press. The tracked hands of the user are represented as a skinny skeleton that allows to see more of the keyboard.

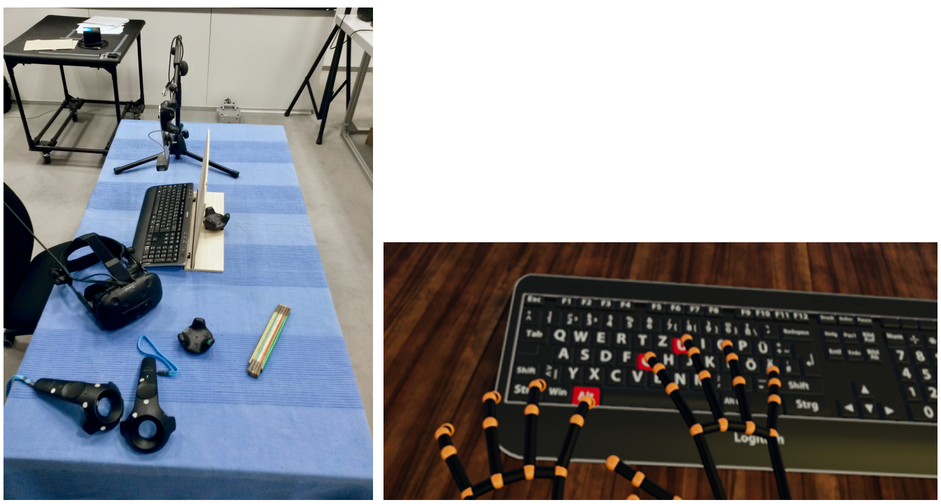

Fig. 3. View on the real keyboard (left) and its virtual counterpart (right).

4 Evaluation

A user study with 13 participants (9 male, 4 female) was performed to evaluate the performance of the approach. Participants were Ø 31.77 ± 12.74 years old. On a scale from 0 (low) to 5 (high) users experience with VR was Ø 1.77 ± 0.93. On the same scale, subjects assessed their typing speed with Ø 3.31 ± 0.63. Users were asked to type three different texts with the three techniques,

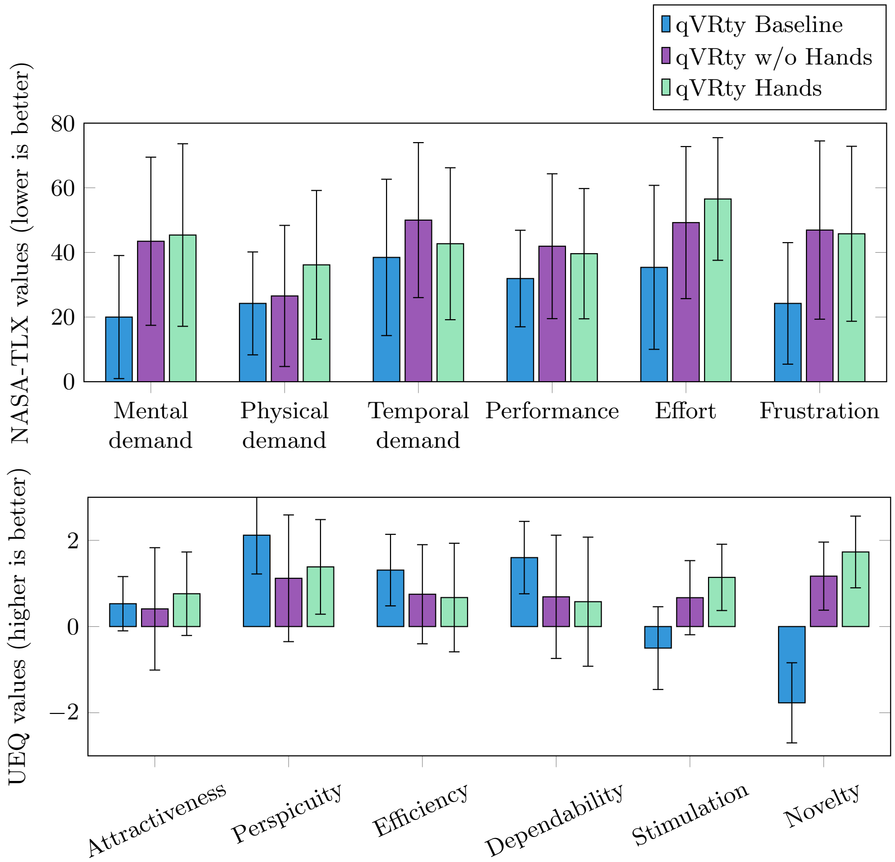

Fig. 4. NASA-TLX and User Experience Questionnaire (UEQ) results of the user study.

typing with a keyboard in real-life as a baseline, qVRty and qVRty without the displayed hands. The order was randomized to compensate training and fatigue effects in the combined results. Before the first round, users were given 3 minutes to accustom themselves with the keyboard. The 1400-characters-long texts contained letters, numbers, german special characters and punctuation marks and were typed sentence by sentence.

The results in Fig. 1 show, our technique is fast in comparison to the related work. The participants achieved Ø 218.7 ± 39.6 cpm with the qVRty baseline, Ø 156.2 ± 71.6 cpm with qVRty and Ø 169.9 ± 65.7 cpm with qVRty w/o hands. The difference between baseline to qVRty, and baseline to qVRty w/o hands is significant ($p \leq 0.000$). qVRty achieves 71% of the baseline speed without any training. Although users only performed one session with each technique, the error rates are average for a keyboard based approach (see Fig. 2). Users achieved error rates of Ø 6.58 ± 3.48 % with the qVRty baseline, Ø 13.43 ± 6.52 % with qVRty and Ø 12.03 ± 5.07 % with qVRty w/o hands.

According to NASA-TLX and UEQ (see Fig. 4), qVRty typing is appealing. The participants rank the mental demand significantly lower in the baseline case compared to qVRty w/o hands ($p = 0.048$). All other differences in the NASA-TLX are not significant. The differences between the results of the UEQ in the categories attractiveness, perspicuity and efficiency are not significant. Subjects rated the dependability between the baseline and qVRty significantly different ($p = 0.026$). The results of stimulation and novelty are significantly different for all pairs with $p \leq 0{,}016$ and $p \leq 0{,}040$ respectively.

Because of some tracking issues, the hands of the users were not displayed the whole time in the qVRty case. On average the hands were displayed Ø 70.34 ± 35.04 % of the time. The minimum and maximum display ratio was 58.88% and 99.82%. However, due to hand tracking issues the efficiency might have suffered.

5 Discussion

The results of the user study show that qVRty with and without hands performs equally well. This shows that the displayed hands were not as helpful as intended. There are two explanations for this. First, the participants are quite experienced keyboard writers as the high baseline shows. Fast 10-finger touch typers do not need to look at the keyboard for most of the time and therefore do not benefit from the displayed hands as much. Second, due to tracking issues the finger location could differ up to 2 cm from the real world which leads to inaccurate hands. However, qVRty is quite fast and reaches 71% of the baseline speed. The faster VR Partial Blending [21] reaches only 65% of the associated baseline.

Besides the fast speed, the error rate of qVRty is very low in comparison to other keyboard-based techniques. Only two of the techniques with more than 100 cpm register a lower total error rate as qVRty with and without hands (VR full and partial blending [21]). All other techniques with a lower error rate are slower.

Although the efficiency loss is significant in the quantitative metrics, the feeling of efficiency as indicated by the UEQ values does not differ significantly from the baseline. The questionnaires show that the mental demand of VR is higher than with the non-VR technique. However, both qVRty with and without hands offer a greater amount of stimulation and novelty. This shows that users still need to adapt to the new medium, but if they do, it can offer additional value.

6 Conclusion

In this paper, a text input method for VR is explored that is based on the well established technique from the desktop pc - the keyboard. A real keyboard and the users hands are tracked and transferred into VR. This allows users to immediately perform fast and accurate text input. The user study shows that

VR technology can benefit from using familiar devices, but can also add novel features. It is possible to adjust the virtual keyboard to not only highlight the currently pressed button, but to change the text on any button according to the current application status. Another feature that can increase user performance with the proposed method is an error correction functionality. Like with smart phones, users could select a word correction by performing a small gesture towards text suggestions that float over the keyboard. For future work we would like to employ a more precise tracking to increase the value of the virtual hands.

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