

# Designing and Comparing Two-Handed Gestures to Confirm Links between User Controlled Objects

Patrick Maier, Marcus Tönnis, Gudrun Klinker \*

Fachgebiet Augmented Reality (FAR)

Technische Universität München, Fakultät für Informatik  
Boltzmannstraße 3, 85748 Garching b. München, Germany

## ABSTRACT

Systems using two-handed spatial manipulation techniques also require strategies to enable system control tasks. These strategies make it possible to interact with the system comfortably while controlling two hand-held objects simultaneously.

The Augmented Chemical Reactions project makes intense use of such two-handed interaction tasks. Users control virtual molecules and subsets that are registered to physical markers and try to combine those by selecting and then confirming a specific bond. When a desired bond has been selected, the user needs a way to confirm that bond without letting an atom go out of position.

We developed and investigated two separate methods of confirming a selected bond when both hands are already doing a two-handed symmetric interaction task. The first method is a waiting method and the second method is a back&forth motion gesture. We evaluated the two methods in a user study, showing that the first technique, holding still, outperforms the other technique.

## 1 INTRODUCTION

Our project “Tangible Chemical Reactions” develops systems for molecular design, enabling users to dynamically visualize 3D models of molecules, to interact and to combine those into larger molecular structures. Those elements are controlled by physically interacting with markers. When two molecules are moved close to each other, all binding possibilities between all atoms with open bonds are computed and the shortest possible bond is visualized with a semi-transparent cylinder. The user can choose a bond by moving the markers so that the two atoms, which are intended to bind, get into nearest proximity. To establish the bond, the user then needs to confirm the choice. The challenge here is how to trigger an event when both hands are already occupied by the markers.

There are some systems that use Augmented Reality for chemistry, e.g., Gillet et al. [4], who have developed a Molecular Biology application. Fjeld et al. [3] have created an AR-based chemical education system that enables students to build molecule models. While these systems use specialized tools to indirectly manipulate virtual objects and their properties, we focus on two handed direct manipulation of the virtual objects and therefore use gestures for system control.

## 2 SYSTEM AND GESTURES

The system was not only developed to support chemists in visualizing molecules and molecular behavior by allowing them to control their position and orientation. The project and thus our system also provides a tool that enable users to build molecules from atoms and reactants and to observe the dynamic spatial relations of binding

possibilities. When multiple open bonds are present, the system provides techniques for selecting any of these bonds [5].

To confirm a specific bond, we developed two different types of gestures to confirm the selection. The first method uses a gesture where the user does not move the markers in the state where the possible bond is shown. The second method is a gesture consisting of a back and forth movement of the markers.

**Waiting Method** The first method is based on passiveness of the user to trigger system events. Such passive methods are often used in systems where a specific subsequent action can be assumed as the next logical step. To give an example, some devices trigger events by detecting that no movement has been occurred, as the RES.Q mobile device from Swissphone [2], which sends an alert, when the device ceases to be moved. Another well-known system is the tooltip element used in programming [6].

When binding molecules, the next step after selecting the desired bond is to confirm its creation. When the user has selected a desired bond, he stops moving the markers and waits for a pre-specified amount of time. After this time period without movement, the selected bond is confirmed and the molecules are bound.

The first implementation of detecting no movement measures the trajectory length of each marker and compared it against a threshold. As an improvement, a second implementation observes the change in length of the possible bond. The difference in the distance of the binding partners from one time step to the next is monitored to determine the gesture. Both implementations sometimes showed drawbacks due to jitter in marker tracking and peaks in trembling. The jitter produces large delta values and the system therefore computes a large sum that exceeds the threshold for gesture detection. A third implementation then was able to neglect these problems by inspecting the minimal and maximal bond length for the last 0.5sec. Contrary to the previous implementation, this version stores the distance of the binding partners in a queue and discards elements that are older than half a second. The system inspects the lowest and the highest value of the stored distances. When the difference of both extrema is smaller than 0.3cm, the system presumes that the markers have not been moved. A jitter, that is lower than 0.3cm in its amplitude is not recognized as a movement, thus making the detection more accurate. We found these thresholds for detecting no movement, by letting an expert group use the system.

The last implementation of this waiting method was then used for the user study.

**Back&Forth Method** We also developed a second gesture, which uses a different concept than the first one. The gesture consists of a back and forth movement of the binding partners (Fig. 1). The user has to move the binding partners twice towards and apart from each other, shrinking or stretching the length of the possible bond by at least 1.5cm. It does not matter if the binding partners are moved first towards or apart from each other. We call this the *back&forth method*. To detect this gesture, the system observes if the length of the bond has changed in an interval between 1sec and 2sec accordingly.

\* e-mail: maierp@in.tum.de, toennis@in.tum.de, klinker@in.tum.de

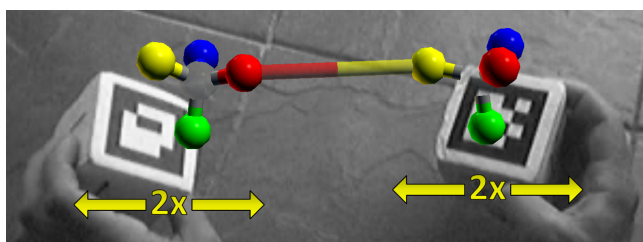


Figure 1: Visualization of the back&forth movement

### 3 EXPERIMENTAL EVALUATION

We set up a user study to determine differences in confirmation speed and acceptance by the user between both methods. After the participants selected specific bonds, they had to confirm these by performing either the waiting or the back&forth method.

For the user study, we asked 20 persons (8 female, 12 male) between the age of 17 and 64 (with a mean age of 36, std. dev. 13) which fits the target group of this application. We displayed two identical molecules (tetrahedron with atom in center Fig. 1) without chemical semantics on the markers to focus on the user interface itself.

#### 3.1 Test procedure

At the beginning of each session, we explained the user the physical setup and gave an overview of the topic of selecting and confirming bonds between two marker-controlled virtual molecules. After the introduction, we asked the participants to fill out the first questionnaire, including questions on demographic data.

We used a within-subject, repeated measures single-session design. The participants then had to select and confirm 24 combinations for the waiting method and 24 combinations with the back&forth method. After 10 participants, we switched the order of the methods to counter-balance and suppress dependencies on a confounding learning effect. After using each confirmation method, we asked participants to complete a SUS questionnaire [1] and to give a short interview. To analyze performance of each method, we measured the time starting at selecting the right combination of atoms until the selection was confirmed.

At the end of the study, the users completed a questionnaire to provide their subjective impressions about the two methods.

#### 3.2 Results

The main goal of our empirical analysis was to determine which confirmation method is superior in terms of perceived confirmation speed and general preference. Even if difficult to compare both methods by time, because both implementations are time dependent, we analyzed time measures. A two-tailed t-test for repeated measures on the time, users needed to confirm the bond, showed no significant difference for the confirmation time.

Looking at the SUS-values, we found a significant difference using a Mann-Whitney-U-Test ( $\alpha = 5\%$ ,  $p < 0.005$ ) in both values. The waiting method ( $\mu = 89.3$ ) for confirming the selection is preferred over the back&forth gesture ( $\mu = 71.8$ ).

From the short interviews, held after each session, we noted that the waiting method was more convenient for the user than the back&forth method, which may have appeared to be more complex than the waiting method. Test participants stated that the waiting method is more convenient. It is like holding objects together to let the glue dry.

Regarding the questionnaire which was filled out at the end of each session, the participants were asked to grade each methods on a 6-point Likert scale (with 1=best to 6=worst) for like/dislike,

easy to use/difficult, fast/slow selection, accurate/inaccurate selection. Figure 2 which presents the results of the questionnaire, shows that the participants had a strong preference for the waiting method.

We used a Mann-Whitney-U-Test to compare both methods according to the answers. The participants liked the waiting method ( $\mu = 1.5$ ,  $\sigma = 0.6$ ) significantly more ( $\alpha = 5\%$ ,  $p < 0.001$ ) than the back&forth method ( $\mu = 3.6$ ,  $\sigma = 1.4$ ). They also found that the waiting method ( $\mu = 1.3$ ,  $\sigma = 0.6$ ) was significantly easier ( $\alpha = 5\%$ ,  $p < 0.001$ ) than the back&forth method ( $\mu = 2.9$ ,  $\sigma = 1.5$ ) in use. According to the subjective perceived time, users thought, that they were significantly faster ( $\alpha = 5\%$ ,  $p < 0.011$ ) with the waiting method ( $\mu = 1.9$ ,  $\sigma = 1.0$ ) than with the back&forth method ( $\mu = 3.0$ ,  $\sigma = 1.4$ ). They thought that they were significantly more accurate in selection ( $\alpha = 5\%$ ,  $p < 0.001$ ) with the waiting method ( $\mu = 1.7$ ,  $\sigma = 0.7$ ) than with the back&forth method ( $\mu = 3.0$ ,  $\sigma = 1.5$ ).

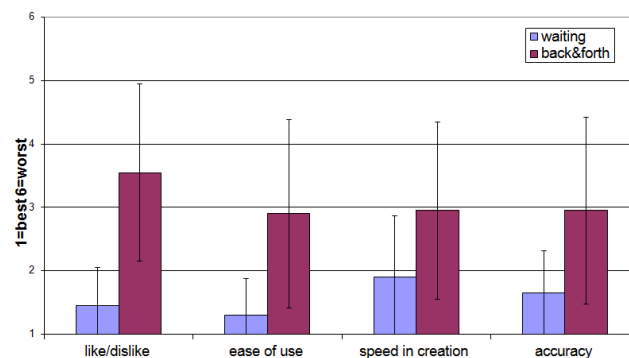


Figure 2: Evaluation of the questionnaire

### 4 SUMMARY AND CONCLUSIONS

We developed and tested new methods for interaction with systems when the user's hands are busy manipulating user-controlled markers. Two implemented methods to confirm a selected bond were tested against each other in a user study. One method uses a waiting gesture and the other method uses a back&forth gesture. From our user study, we found that the method of waiting and not moving the markers is the preferred gesture for confirmation of a selection.

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