# FingerOscillation: Clutch-free Techniques for 3D Object Translation, Rotation and Scale 

Siju Wu, Amine Chellali, Samir Otmane

## To cite this version:

Siju Wu, Amine Chellali, Samir Otmane. FingerOscillation: Clutch-free Techniques for 3D Object Translation, Rotation and Scale. The 20th ACM Symposium on Virtual Reality Software and Technology (VRST 2014), Nov 2014, Edinburgh, United Kingdom. pp.225-226, 10.1145/2671015.2671117. hal-01078602

HAL Id: hal-01078602

## https://hal.science/hal-01078602

Submitted on 8 Nov 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# FingerOscillation: Clutch-free Techniques for 3D Object Translation, Rotation and Scale 

Siju Wu,* Amine Chellali ${ }^{\dagger} \quad$ Samir Otmane ${ }^{\ddagger}$<br>IBISC Lab, Evry University, France


#### Abstract

In this paper, we present three freehand interaction techniques for 3D content manipulation, the FingerShake, for object translation, the FingerRotate, for object rotation and the FingerSwing for object scale. These three techniques refer to a more generic concept which we call FingerOscillation. The main contribution is to interact with the machine by using finger oscillation movements. We introduce the design and the implementation of these techniques.


Keywords: freehand gesture, 3D object manipulation, remote control, oscillatory motion.

## 1 Introduction

With the help of tracking devices such as the Kinect, it is possible to make remote interaction by using freehand movements in air. However, using freehand movements to manipulate objects displayed on the display intuitively and efficiently is still a challenge task. In this paper we present three techniques, the FingerShake, the FingerRotate and the FingerSwing, to manipulate objects in the 3D environment by using only finger movements. These techniques are inspired by the CycloStar which is presented in [Malacria et al. 2010] and can be generalized by a more generic concept, which we name the FingerOscillation.

## 2 FingerOscillation

The FingerOscillation is an approach to generalize techniques based on straight and circular periodical 3D finger movements by an elliptic oscillatory model. This model is an extension of the 2D model proposed in the work of [Malacria et al. 2010].

The FingerOscillation has several important properties:

- Humans are apt to make reasonably accurate cyclic gestures after training. The hand structure makes it easy to oscillate the hand in a quasi-harmonic fashion.
- Oscillatory gestures allows more continuous control of variables to be manipulated than other gestures such as dragging and pinching. Clutching can be avoided when repeating the same gesture.
- When performing oscillatory finger movements, hand and arm movements of large range are avoided and fewer muscles are involved in. The user can keep the hand in a relatively

[^0]small space in front of the chest. Interaction process becomes less tiring.

- The user does not need to change the hand posture to indicate the onset and the end of the manipulation explicitly.


## 3 FingerShake

The FingerShake is designed to translate virtual objects in the 3D space by using to-and-fro oscillatory finger gesture. This technique is inspired by the CycloPan proposed in [Malacria et al. 2010] and it is an extension of the CycloPan in the 3D space. To translate an object, the index finger should be dragged in the wanted direction (Figure 1). After the first stroke finishes, a second stroke can be done by dragging the index finger in the opposite direction. The object continues moving in the same direction although the stroke direction reverses. By dragging the finger forward and backward alternatively, the object keep translating in the initial direction until the finger stops moving. The translation distance and speed can be controlled by the amplitude and frequency of finger movements.


Figure 1: Perform the FingerShake to translate an object.

### 3.1 Implementation

To translate an object by using linear finger oscillation, first it is necessary to segment the finger trajectory to different strokes. For each frame, we check the curvature of the finger trajectory around the new generated finger position. If the curvature is small, the new finger position belongs to the active stroke. Otherwise we segment the trajectory and a new stroke is generated.

If the FingerShake is inactive, we check whether the new generated stroke satisfies a set of conditions to start the translation. Because the FingerShake requires the user to drag the finger in a linear way, so first we check whether the stroke can be fitted to a line. To avoid triggering the FingerShake involuntarily, the average speed of the starting stroke should exceeds $150 \mathrm{~mm} / \mathrm{s}$. In addition, it is also necessary to limit the length of the stroke, otherwise the FingerShake can be launched by a long drag gesture. In our implementation, we set the maximum length of the first stroke to 120 mm .

Once the FingerShake starts, the direction of the first stroke is chosen as the translation direction. The translation amplitude is calculated by using the following functions:

$$
\begin{equation*}
f_{i}=\frac{1}{2} *\left(T_{\text {end_ } i}-T_{\text {start }^{\prime} i}\right) \tag{1}
\end{equation*}
$$

$$
\begin{gather*}
g_{i}=\max \left(1, k_{1} * \frac{1}{3} * \sum_{i-2 \leq j \leq i} f_{j}\right)  \tag{2}\\
d_{n}=\sum_{1 \leq i \leq n} g_{i} * a_{i} * k_{2} \tag{3}
\end{gather*}
$$

where $f_{i}$ is the frequency of the $i^{\text {th }}$ stroke. $T_{\text {start_i }}$ and $T_{\text {end_ } i}$ is the starting and end time of the $i^{t h}$ stroke. $g_{i}$ is the gain value which is used to control the translation amplitude. $d_{n}$ is the total translation distance of the object and $a_{i}$ is the amplitude of the $i^{t h}$ stroke. $k_{1}$ and $k_{2}$ are two ratio parameters. The use of $g_{i}$ makes it possible switch the translation velocity. To avoid jerky speed variations, the calculation of $g_{i}$ takes use of the frequency of the last three strokes. The translation stops when the length of finger movement is shorter than 10 mm in 5 continuous frames.

## 4 FingerRotate

Similar to the FingerShake, the FingerRotate is also inspired by the work of [Malacria et al. 2010]. We have extended the concept of CycloZoom + to the 3D space. To rotate an object, the user has to oscillate the index finger in a circular way (Figure 2). Once a quasi-circle is drawn by the first stroke, the FingerShake is activated. The first stroke is fitted to a circle and the normal vector of the circle is used to determine the rotation axis. After that the object can be rotated around the selected axis by continuing the same finger movement. The rotation speed can be controlled by the circle radius.


Figure 2: Perform the FingerRotate to rotate an object.

### 4.1 Implementation

When dragging the finger in a circular way, the direction of the index movements changes fluently, so there is no jerky change of the trajectory curvature. We have proposed another algorithm to make stroke segmentation. For each frame, we approximate the active stroke to an arc segment of a circle and check the angle corresponding to the arc segment. When a complete circle is drawn, the angle reaches $360^{\circ}$. At this time the FingerRotate is activated and the finger trajectory is segmented to generate a new stroke. When the user continue drawing a circle, we do the same thing to the new stroke to check the angle variation. Every time a complete circle is drawn, the center and the radius of the circle are saved. The normal vector of the circle is chosen as the rotation axis. For each frame, the rotation angle of the object is calculated by using the following function:

$$
\begin{equation*}
a_{i}=\frac{\left\|Q_{i-1} Q_{i}\right\|}{R} * k_{3} \tag{4}
\end{equation*}
$$

where $a_{i}$ is the angle variation. $Q_{i-1}$ and $Q_{i}$ are the projection points of the $(i-1)^{t h}$ and $i^{t h}$ point of the stroke. $R$ is the radius of the fitting circle and $k_{3}$ is a ratio parameter.

## 5 FingerSwing

We have proposed a technique, which is named FingerSwing, to make uniform scale of an object. The object can be magnified (or
shrunk) by repeating drawing the upper (or the lower) part of an circle in the plane parallel to the display (Figure 3).


Figure 3: Perform the FingerSwing to scale an object.

### 5.1 Implementation

The stroke segmentation of the FingerSwing can be done by the same algorithm of the FingerShake. When the first stroke of the FingerSwing finishes, the system tries to fit the first stroke to an ellipse. If both of the long axis and the short axis of the fitting ellipse are longer than 4 mm , the system waits for the second stroke. When a drag direction reverses again, we compare the directions of two strokes. If they are performed in opposite directions, for example one in clockwise and the other in anticlockwise, the FingerSwing is recognized. After that, every time the stroke direction is reversed, the system uses the last two strokes to fit a circle. The scale of the object is refreshed by using the following function in each frame:

$$
\begin{gather*}
b_{i}=\frac{\left\|Q_{(i-1)} Q_{i}\right\|}{R}  \tag{5}\\
s_{i}=s_{i-1} *\left(1+k_{4} * b_{i}\right) \tag{6}
\end{gather*}
$$

where $s_{i}$ is the scale of the object in the $i^{t h}$ frame. $b_{i}$ is the radian distance between the $(i-1)^{t h}$ and $i^{t h}$ stroke point projections on the fitting plane. $R$ is the radius of the fitting circle and $k_{4}$ is a ratio parameter.

## 6 Setup

We have implemented all the three techniques in a Thinkpad T510i laptop with a screen of 15 inches. A Leap Motion controller locates in front of the laptop and is used to capture hand and finger movements. The application development is done in the environment of the Unity3D by using C\#.

## 7 Conclusion and perspectives

In this paper we present three techniques, FingerShake, FingerRotate and FingerSwing for object manipulation. All the three techniques refer to a more generic concept which we call FingerOscillaiton. In the future work, we want to compare the performance of the FingerOscillation with some other object manipulation techniques. We are going to make several experiments to examine the efficiency and the precision of our techniques.

## References

Malacria, S., Lecolinet, E., and Guiard, Y. 2010. Clutchfree panning and integrated pan-zoom control on touch-sensitive surfaces: the cyclostar approach. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM, 2615-2624.


[^0]:    *e-mail:siju.wu@ibisc.univ-evry.fr
    $\dagger$ amine.chellali@ibisc.univ-evry.fr
    $\ddagger$ e-mail:samir.otmane@ibisc.univ-evry.fr

