

# Weighted Integral Rotation and Translation for Touch Interaction

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## 1 Introduction

Touch based interaction is popular in graphical user interface (GUI) systems, as it provides natural and intuitive direct manipulation. Rotation and translation are basic tasks for manipulating graphical objects and various touch based interaction techniques has been investigated for doing this [Hancock et al. 2006]. In early GUI systems, users had to perform rotation and translation independently by switching between the two manipulation modes either using a menu system or by manipulating different widgets that in many cases make the interface visually cluttered. Recently, two-finger gestures have become common in multi-touch interfaces to perform rotation, translation, and even scaling, simultaneously, without visual clutter. However, there can be ergonomic problems when the user has to rotate objects in large angle [Hoggan et al. 2013], which causes strain on user's wrist. As a result users tend to split and perform the manipulation in multiple steps, which might not be suitable for certain applications, such as puppeteering based animation tools.

## 2 Weighted Integral Rotation and Translation

With the Integral Rotation and Translation (RNT) [Beaudouin-Lafon 2001; Kruger et al. 2005] technique, users can perform both rotation and translation in an integrated way using only one finger. Hence it does not have the ergonomic problems found in two-finger gestures. RNT mimics physical manipulation of flat objects (e.g. paper) on a table, where the friction between the object and the table surface generates torque around the object's center of gravity. When an object is dragged from  $T_0$  to  $T_1$  using the RNT technique, it is also rotated about  $T_1$  by the angle  $\theta$  ( $= \angle T_0 O_0 T_1 = \angle O_1 T_1 O_0$ ), so that the final center of gravity  $O_2$  is on the line of  $O_0 T_1$  (see left side of Figure 1).

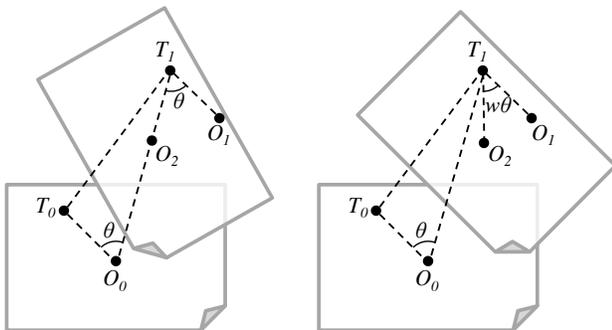


Figure 1: RNT (left) and wRNT (right).

While the RNT method provides intuitive integration of rotation and translation, rotation cannot be applied when  $T_0 = O_0$ . To avoid this, Kruger et al. [2005] had a region around the center of gravity where only translation is applied. However, this could be confusing to the user as the context of manipulation switches suddenly at the

boundary of such region. One solution is to visually mark the region to help users to recognize the boundary, but this also increases on-screen visual clutter.

In our research, we overcome these problems by introducing a weight factor to the amount of rotation integrated to translation. We call the method Weighted Integral Rotation and Translation (wRNT). As shown on the right side of Figure 1, we multiply the weight  $w$  ( $0 \leq w \leq 1$ ) to the rotation angle  $\theta$  to control the amount of rotation. The weight is proportional to the distance  $d$  between the touch point  $T_0$  and the center of gravity  $O_0$ , and it can be calculated with a simple function such as the proportion of  $d$  to the radius of the object  $r$ . To create a smoother transition, the weight can be mapped using sigmoid functions such as a partial sine wave or logistic function. The weight function can also be used when  $T_0 T_1$  is perpendicular to  $O_0 T_0$ . In this case we set the value to 1 to support full rotation.

Figure 2 shows our implementation of the wRNT technique on an Android tablet. Dragging different points on the same object results in different weights being given to the integrated rotation while translating the object. In the future, we plan to conduct a user study to investigate the strengths and weaknesses of the technique, and apply it to a puppeteering based animation tool.

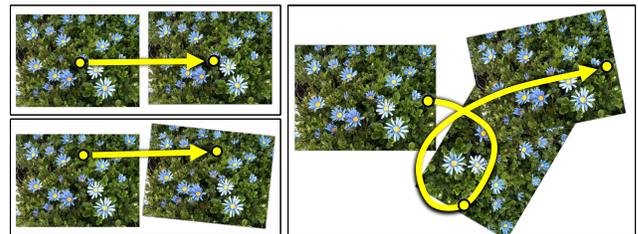


Figure 2: Dragging different points on the same object using wRNT (yellow dots and arrows show touch points and dragged directions).

## References

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