Technical Description of Eruler

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As an innovative smartphone app implemented in Swift3, Eruler measures the length of a distant or large object that cannot be obtained by traditional rulers. Unlike other similar apps, a reference input is not required. Instead, Eruler utilizes images taken in two different positions chosen by user to calculate length based on phone displacement measured by built-in sensors. Due to this procedure, Eruler has two major technical difficulties. One is displacement measurement by sensors, the other one is length calculation by images and displacement.

Displacement Measurement

In developing displacement measurement, we choose to collect data from accelerator instead of barometer because the altitude outputs from barometer are very unstable and fluctuate much even in stationary state, causing significant deviation in small distance (< 10 cm). In contrast, the raw acceleration data can be corrected to derive a precise displacement.

A test procedure is applied to calibrate raw data, as shown in Figure1. To adjust data, we first plot raw data in Matlab, integrate it to obtain velocity plot, and correct the data by a self-designed algorithm on the velocity. In Figure 2, the supposedly zero velocity calculated from integration is negative at the end, and after filtering velocity decreases exponentially from max to zero. In Figure 3, double integration accumulates significant error, but adjustment makes displacement almost exact value (50 cm).

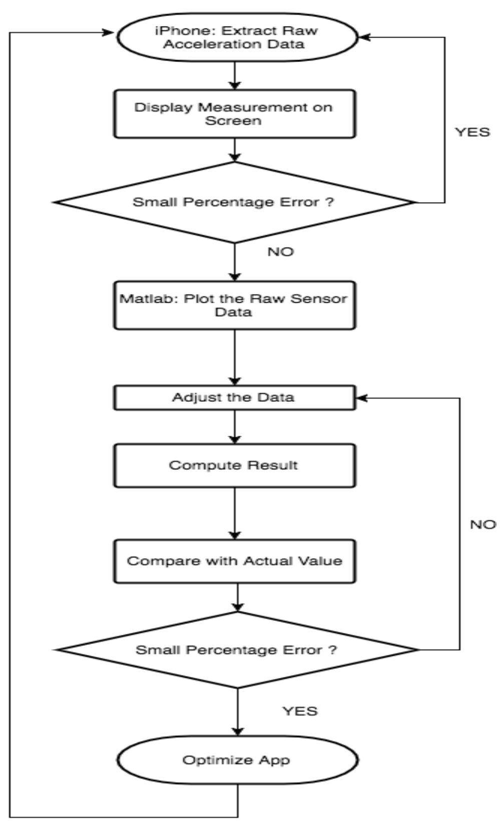


Figure 1. Displacement Test

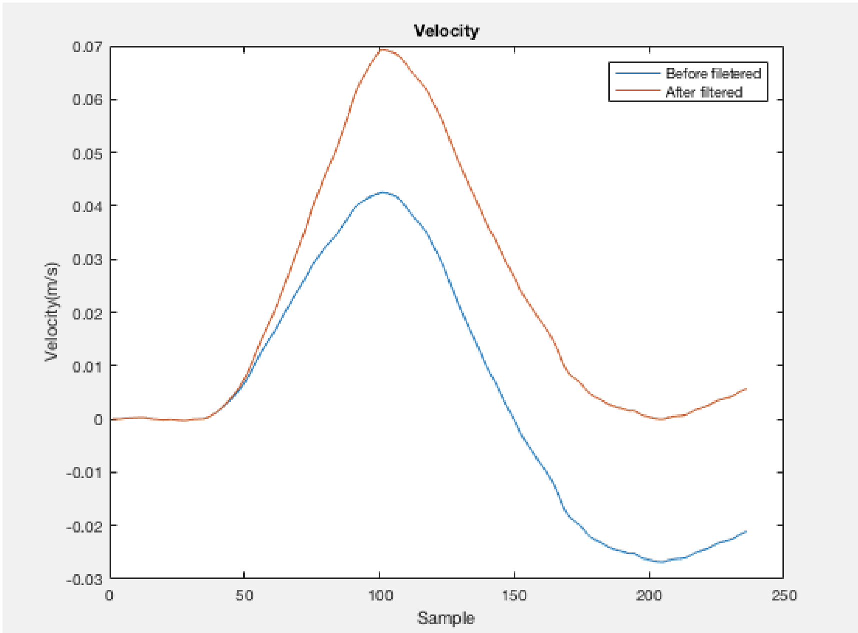


Figure 2. Velocity Plot Before and After Adjustment

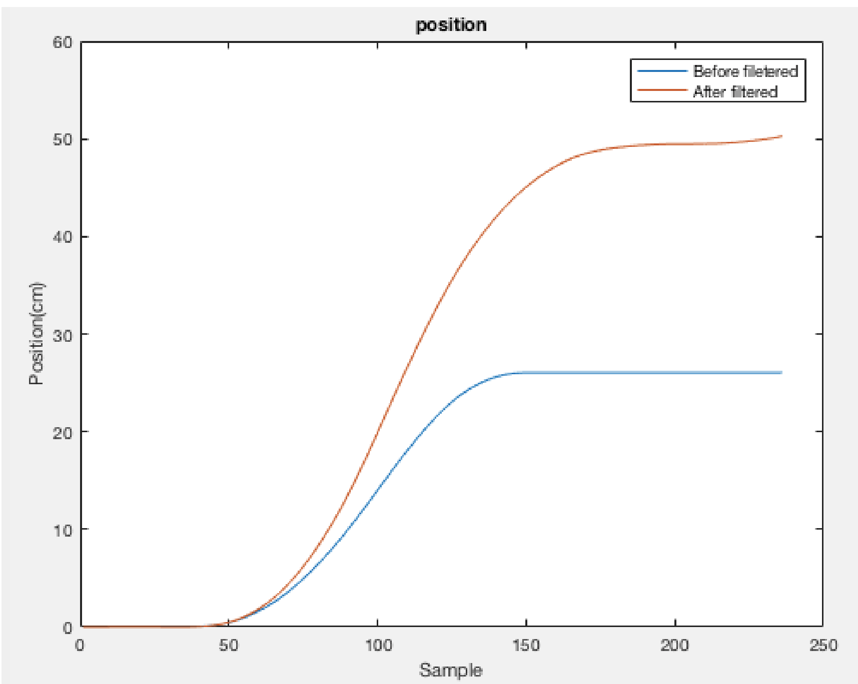


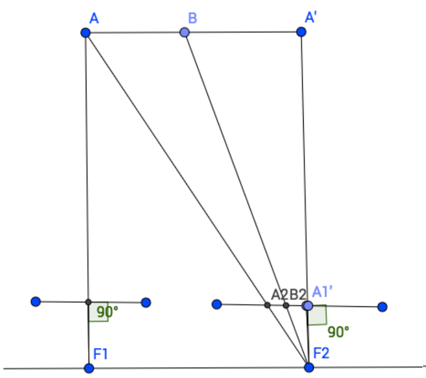
Figure 3. Position Plot Before and After Adjustment

In current stage, the error range on measuring distance is 6.5%, and by creating a three-dimensional data adjustment method, we can reduce the error caused by minor hand movements in directions other than downward.

Length of Object Measurement

To calculate the length of object, we extract two basic mathematical models to simulate usage process for measuring length between point A and B. In figures below, F1 and F2 are focus positions when taking photos, F1F2 represents phone displacement, and all angles are arbitrary unless marked with 90 degrees. Both Figure 4 and Figure 5 are in ideal condition where point A goes through the middle of image on screen and lens. In current stage, we have accomplished simulation of ideal condition without rotation shown in Figure 4, with an error range of 5.7%.

To increase precision, we can calculate the pixel angle <PA2, <PB2 from second image and get <A1'GF2 by gyroscope. Thus, we can calculate the length AB by solving the triangle displacement and angles in Figure 5 and Figure 6.



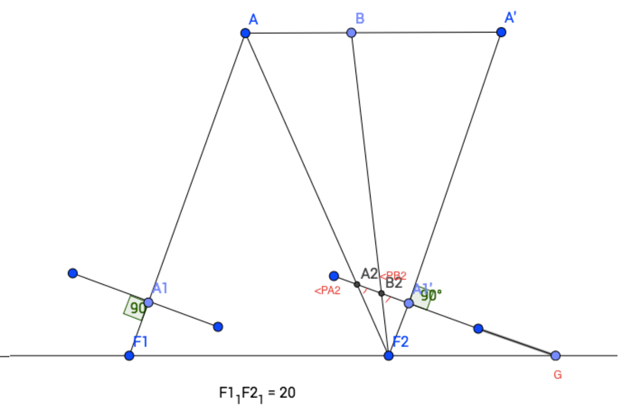


Figure 4. Ideal Condition without Rotation   Figure 5. Ideal Condition with Rotation

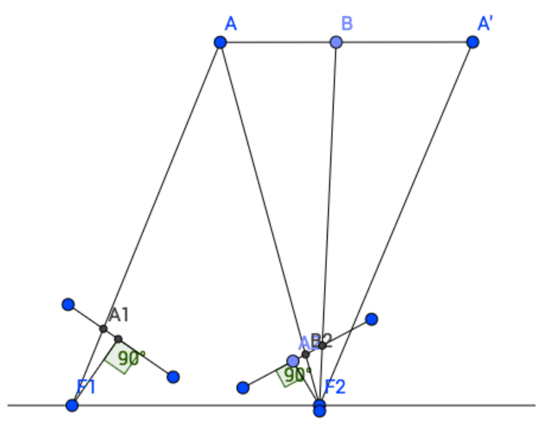


Figure 6. Complicated Condition

We expect to decrease error percentages by introducing three-dimensional movements and rotations into account to derive more precise results, while allowing users to take photos in any two positions and angles.