iRotate Grasp: Automatic Screen Rotation based on Grasp of Mobile Devices

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ABSTRACT

Automatic screen rotation improves viewing experience and usability of mobile devices, but current gravity-based approaches do not support postures such as lying on one side, and manual rotation switches require explicit user input. iRotate Grasp automatically rotates screens of mobile devices to match users' viewing orientations based on how users are grasping the devices. Our insight is that users' grasps are consistent for each orientation, but significantly differ between different orientations. Our prototype embeds a total of 32 light sensors along the four sides and the back of an iPod Touch, and uses support vector machine (SVM) to recognize grasps at 25Hz. We collected 6-users' usage under 54 different conditions: 1) grasping the device using left, right, and both hands, 2) scrolling, zooming and typing, 3) in portrait, landscape-left, and landscape-right orientations, and while 4) sitting and lying down on one side. Results show that our grasp-based approach is promising, and our iRotate Grasp prototype could correctly rotate the screen 90.5% of the time when training and testing on different users.

ACM Classification: H5.2 [User Interfaces]: Input devices and strategies, Interaction styles; H1.2 [User/Machine Systems]: Human factors

General terms: Design, Human Factors

Keywords: Auto Rotation; Grasp Recognition; Device orientation;

INTRODUCTION AND RELATED WORK

Modern mobile devices, such as the iPhone, iPad, Android phones, and tablets, all support automatic screen rotation in order to improve the viewing experience and usability. Current gravity-based approaches assume that users are standing or sitting upright while using the devices, which causes the screen to rotate incorrectly when users are in near horizontal postures, such as when lying down on one side. Our previous survey of this approach (n=513) [3] shows that 91% of the respondents have experienced incorrect auto rotation, with 42% of the respondents encountering the problem several times a week.

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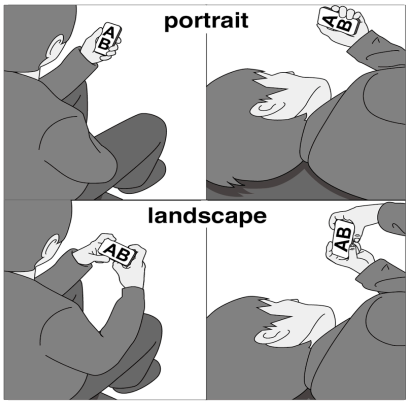

Figure 1: Example grasps of a smartphone in portrait and landscape orientations: a user's grasp remains consistent even while sitting and lying down, but is significantly different between screen orientations.

Our previous work, iRotate [3], used face detection to track a user's intended viewing orientation, rotating the screen accordingly. However, in many cases a user's face may not be clearly visible. Another common solution to the screen rotation problem is providing an auto-rotation lock to fix the current screen orientation. Several gestures have been proposed to temporarily override the auto-rotation setting [4,5,7]. However, the techniques still require explicit user input and require the user to learn new gestures as well.

To overcome the challenges of existing automatic screen rotation systems, we present iRotate Grasp, a system that automatically rotates a mobile device's screen based on a user's grasps. We were inspired by several grasp-based user interface researches [6,8,9,10]. Our insight is that a user's grasp is consistent for a given viewing orientation, but is significantly different between screen orientations. Figure 1 shows examples of grasps in different postures for both portrait and landscape modes. iRotate Grasp senses how a user holds the devices, and uses machine learning to

learn how various grasps map to intended screen orientations.

DESIGN AND IMPLEMENTATION

Figure 2: Photos of iRotate Grasp prototype, showing an iPod Touch, an Arduino board, 2 multiplexers, and 32 light sensors inside an iPhone 4S case.

In light of SideSight [1] that used light sensors to detect the presence and position of fingers around the device, we implemented a grasp sensing prototype by embedding 32 light sensors and an iPod Touch 4 inside an iPhone 4S case in order to explore how well grasp can be used to infer the correct screen orientation. The light sensors are connected to the iPod Touch via an Arduino Pro Mini 328 that connects to iPod Touch's serial port. The prototype, as shown in Figure 2, is similar in size to iPhone 4S and its weight is 150g, 10g heavier than iPhone 4S. In order to train our system to recognize the mapping between grasps and orientations, we recruited 6 participants (3 female, age 21-27) and asked them to perform the following 54 conditions twice:

- grasping the device using left, right, and both hands (3) x
- and scroll, pinch-to-zoom and type (3) x
- while sitting and lying down on one side (2) x
- in portrait, landscape-left, and landscape-right orientations (3).

We sampled the light sensors at 30Hz for a total of 194400 (6 users x 54 tasks x 10 seconds x 2 trials x 30Hz) grasp recordings, and we use LIBSVM [2], a support vector machines library, for the grasp orientation recognition. The results of 6-fold, subject-independent cross validation, in which we train with 5 users' data and test on the 6th user, shows 90.5% accuracy in average (as shown in Figure 3).

Classified as →	a	b	c	Accuracy
a=portrait	100034	1346	3633	95.26%
b=landscapeLeft	4210	85182	8043	87.42%
c=landscapeRight	4224	6922	85859	88.51%

Figure 3: Confusion matrix of subject-independent cross validation (6-fold, leave-one-subject-out).

CONCLUSION AND FUTURE WORK

We demonstrated that grasps could be used to automatically rotate screens to match users' view orientation with high accuracy. Currently, we are investigating combining grasp and computer vision-based approaches, which might be more robust in real-world environment.

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