

Demo: E-Gesture – A Collaborative Architecture for Energy-efficient Gesture Recognition with Hand-worn Sensor and Mobile Devices

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ABSTRACT

We demonstrate *E-Gesture*, a collaborative architecture for energy-efficient gesture recognition on a hand-worn sensor device and an off-the-shelf smartphone that greatly reduces energy consumption while achieving high accuracy recognition under dynamic mobile situations. E-gesture employs a novel gesture segmentation and classification architecture carefully crafted by studying sporadic occurrence patterns of gestures in continuous sensor data streams and analyzing energy consumption characteristics in both sensor and smartphone.

Categories and Subject Descriptors

C.3[Computer Systems Organization]: Special-Purpose and Application-Based Systems

General Terms

Design, Experimentation, Management

Keywords

Gesture recognition, Energy efficiency, Mobility

1. INTRODUCTION

Recently, a smartphone has become an everyday companion that a user stays with and keeps interacting with. Unlike conventional keyboard and touch based interactions, hand gestures enable simple and intuitive interaction not necessarily taking out the phone and paying considerable visual attention. With a support of gesture-based mobile UI, the user can seamlessly interact with various mobile applications without taking her eyes off the road while driving or slowing her pace down while jogging.

An important challenge in designing a system to support gesture-based mobile UI lies in efficient use of strictly limited energy of mobile and sensor devices while dealing with dynamically changing mobility situations of the user. Typical systems consisting of a hand-worn sensor node and a mobile device [1][3] require continuous turn-on of power-hungry sensors and radio transceivers, threatening the battery life of both devices. Besides, gesture processing becomes more complex as the user's situation varies while she moves around. Body movements under different mobile situations incur different characteristics of mobility-noise, thereby resulting in different sensor data for the same hand gestures. Hence, the prevalence of mobility noise and non-gestural movements should be carefully considered for the design of a gesture-based mobile UI system.

We demonstrate *E-Gesture*, a collaborative architecture for energy-efficient gesture recognition that greatly reduces energy consumption while achieving high accuracy recognition under dynamic mobile situations.

2. ARCHITECTURE OVERVIEW

Segmentation Architecture: We propose *closed-loop collaborative segmentation architecture* in sensor-side, which combines advantages of two different segmentation methods based on accelerometer and gyroscope. That is to selectively turn-on and use high-energy, high-accuracy gyro-based segmentor only for validating the gesture segments detected by low-energy, low-accuracy accel-based segmentor,

thereby achieving low-energy as well as high-accuracy. Moreover, gyro-based segmentor continuously reconfigures accel-based segmentor to adapt the dynamic changes of mobility situations, through monitoring false-segmentation rate. It brings clear benefits in terms of resource feasibility, energy efficiency, and mobility robustness. First, it is light-weight enough to be implemented in the resource-scarce sensor node, as it utilizes a simple but effective threshold-based algorithm. Second, selective and deliberate activation of the gyroscope achieves considerable energy saving and a high level of segmentation accuracy.

Classification Architecture: In addition to energy-efficient architecture, we elaborate the gesture classification architecture to effectively deal with different mobility situations. We developed two HMM architectures: (1) *adaptive* and (2) *multi-situation HMM architecture*. Adaptive HMM adapts well with current mobility situation as it continuously updates the HMM models. The Multi-situation HMM achieves the best accuracy under known mobility situations by training HMM for each mobility situation in advance.



Figure 1 Demonstration Setup

3. DEMONSTRATION SETUP

Implementation Detail: We have implemented an E-Gesture prototype using wearable sensor node, i.e., a wrist-watch type KMote with TinyOS, and off-the-shelf mobile devices i.e., Nokia N96 and Google Nexus One. We partially ported the widely-used HMM Toolkit, i.e., HTK [2], to the smartphones. Our results show that E-Gesture is able to achieve energy efficiency of the sensor device and the mobile device by up to 2.4 times and 2.8 times respectively, and classify gesture candidates into 8 gesture types at an average accuracy of 94.6% under dynamically changing mobility situations, including standing, riding a car, walking, and running. Note that using HMMs trained for standing situation accounts only for 69.78% of accuracy under the same setting.

Demo Setup: As shown in Figure 1, we demonstrate the behavior of E-Gesture architecture with KMote wristwatch type sensor and Google Nexus One. We compare our architecture to an ordinary one which does not consider mobile and resource-limited environment, in terms of energy-efficiency and mobility-robustness.

4. REFERENCES

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