Expanding Touch Interaction Capabilities for Smart-rings: An Exploration of Continual Slide and Microroll Gestures

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1. Background & Objectives

- Smart-rings are becoming increasingly feasible through miniaturized, and powerful, hardware
- Touch interaction on smart-rings are currently limited to simple taps and swipes
  - This limits usage and thus adoption
  - While other input modalities exist, we recognize that we live in a touch input world

Motivation:
Expand touch interaction vocabulary and capability for smart-rings, a small and low-resolution device

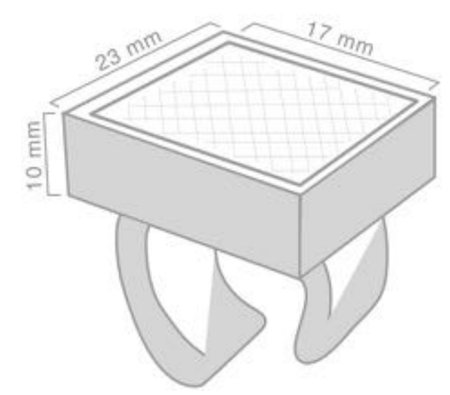
- To expand touch interaction, *micro gestures* can be used:
  - Bezel- [3] and pressure- [4] based interactions have been explored, however provide location dependent and discrete interactions respectively
  - Roudaut et al. [1] explored *MicroRolls* and Bonnet et al. [2] explored thumb rocking on smartphones with success (qualitatively and quantitatively)
    - These gestures allow for use within a small area and can be used across the device

Objective:
From the success of microrolls, employ continual, location independent, slide and microroll gesturing on a smart-ring

Contributions:
1) An RF model, with 92.4% accuracy, that discerns slide and microroll gestures on a smart-ring within the same touch instance and in real-time;
2) Proposed applications that can benefit from the increased interaction space, including a discussion of implications and future work

2. Methods

- Utilizing custom, built in-house, smart-ring hardware we 1) captured slide and microroll gestures, 2) processed the data, and 3) trained 4 models to discern the slides and microrolls



Custom Built Smart-Ring

We built a custom smart-ring with a 17x17 mm capacitive touch surface. For further hardware details, please see our paper.

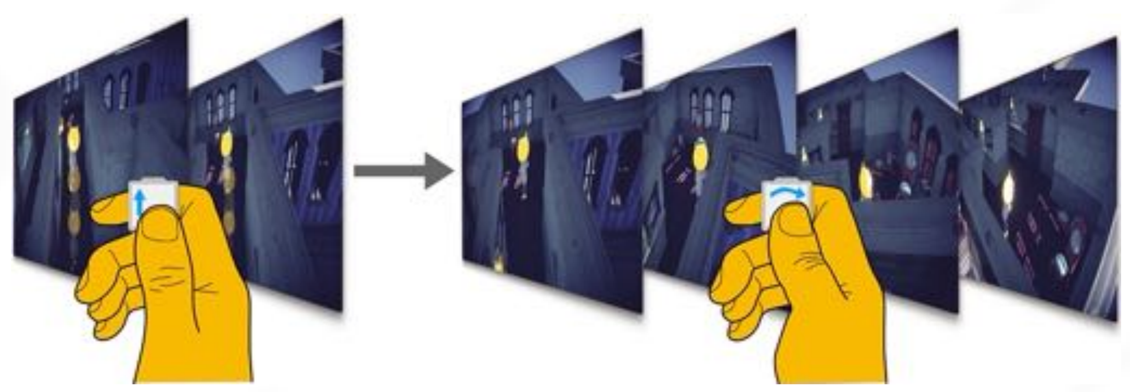
1. Data Collection
   - 7 volunteers (1 woman, 6 men; 25-30 years; limited to no experience with a smart-ring)
   - 10 sessions per volunteer with 24 slides and 24 microrolls captured per session
     - Each gesture was captured separately with the gesture (type, location, and direction) randomized
     - Total of 1680 slides and 1680 microrolls
2. Data Processing
   - Randomly concatenated all separately captured gestures into a single series (restricted to concatenated gestures ending and starting within a set minimum distance)
     - Allows for us to not exhaust a participant into performing all combinations of continual slide and microroll gestures
     - New randomized series can be created which provide new datasets for model training
   - Extracted 18 features from the data across 91804 samples using a sliding window approach and minority re-sampling on the slide samples
3. Model Generation and Evaluation
   - Binary classification was used for complexity reduction and as directionality can be discerned through analysis of the touch points
   - 80/20 stratified split of the data for training and testing
   - The Random Forest model provided the highest accuracy with 92.4%, further tested with with 5-fold cross validation at 90.6% accuracy

3. Applications

- The following two applications demonstrate the potential of continual slide and microroll gestures using a smart-ring
- Importantly, our implementations do not require a delimiter to switch between interaction modalities
- Our applications were built for a Samsung Galaxy S8 running Android. To avoid memory limitation issues, we hosted our model on a local Python server with an API endpoint for touch data and model prediction communication

Map Navigation

Here, the user can pan around the map using slidegestures (image left depicts sliding to the right). When needed, the user can zoom-in or -out using upand down microrolling gestures respectively (image right depicts zooming-in through an upward microroll).



Game/Character Control

Here, the user slides up to have the character move up through the hall. Then, the user microrolls to the right to have the camera circle around the character before being able to move back to a slide to keep the character walking

SCAN ME FOR DEMO VIDEOS

4. Discussion & Future Work

- While not tested here, according to Roudaut et al. [1] microrolls have the potential to outperform certain menuing techniques and were a highly rated interaction
- Slides and microrolls have similarities, however noticeable differences can be seen in the pressure, distance travelled, and speed features
- Current limitations include:
  - Sliding window size versus accuracy and the prediction of gestures at natural speed
  - Lack of on-board memory for local gesture prediction and limited Bluetooth transmission rates
- Future work will explore:
  - Full study exploring increased directionality and improvement upon current model accuracy
  - Applications such as smart-ring text entry and increased usage scenarios such as while on-the-go and/or eyes-free

5. Conclusion

- This work provides an early look at our research focusing on expanding interaction capabilities on smart-ring devices and our broader research goal of allowing smart-rings to become increasingly feasible devices for use within our daily lives.

Takeaways:
1) Unique data capturing and processing steps to aid in simple data capture and model generation
2) Real-time classification of location independent slides and microrolls within the same touch instance; using a Random Forest model with 18 features we achieved a 92.4% accuracy
3) Successful expansion of touch interaction capabilities for a smart-ring, a small form factor and low touch resolution device

Affiliations

Acknowledgements

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