SoK: Authentication in Augmented and Virtual Reality

Sophie Stephenson, Bijeeta Pal, Stephen Fan, Earlence Fernandes, Yuhang Zhao, Rahul Chatterjee
AR and VR devices need authentication.
Why not passwords?

- Poor usability
- Poor security
AR/VR present unique possibilities

- microphone
- touchpad
- IMU sensor
- audio feedback
- haptic feedback
- inward camera
- outward camera
- controllers
- visual feedback
Our work

Survey of 139 users, including 49 developers

7 methods used in 178 current apps

43 methods proposed in 38 prior works

evaluation criteria for AR/VR authentication
Our work

Part 1

Survey of 139 users, including 49 developers

evaluation criteria for AR/VR authentication

7 methods used in 178 current apps

43 methods proposed in 38 prior works
Surveying users & developers

Designed a survey to ask:
• What do users think?
• Which authentication methods do developers choose? Why?

Recruited participants on online platforms (e.g., Reddit, AR/VR Slack groups)

Defined evaluation criteria by coding qualitative responses

139 users
49 developers
Properties for evaluation

Deployability
- OS-Supported
- Platform-Agnostic
- Mature
- Low-Power-Cons.

Usability
- Efficient-to-Use
- Physically-Effortless
- Memorywise-Effortless
- Easy-to-Learn
- Nothing-to-Carry
- Infrequent-Errors
- Acceptable-in-Public

Accessibility
- Accessible-Visual
- Accessible-Hearing
- Accessible-Speech
- Accessible-Mobility
- Accessible-Cognitive

Security
- Resilient-to-Guessing
- Resilient-to-Observation
- Protects-User-Privacy
- Multi-Factor

See paper for details!
Survey of 139 users, including 49 developers

evaluation criteria for AR/VR authentication

Part 2

7 methods used in 178 current apps

43 methods proposed in 38 prior works
Analyzing authentication in AR/VR apps

1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Incumbent knowledge-based methods

- Password
- PIN

Great deployability
(e.g., Platform-Agnostic)

- Bad usability & accessibility
(virtual keyboard)

- Worse security than on other devices
(e.g., shoulder surfing)

1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Incumbent token-based methods

Better security (e.g., Resilient-to-Guessing)

Better usability (e.g., no virtual keyboard)

Require a secondary device

QR code

Short code

1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Automatic paired account

1. User logs into Viveport account
   username: sophie
   password: hunter2

2. User puts on headset and opens app

3. User is **automatically authenticated**

You are logged in!
Most promising incumbent methods

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**Automatic paired account**

- Great **usability** & **accessibility**
- Strong **security** (e.g., Resilient-to-Observation)
- **Deployable**
- Potential privacy issues

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**Iris scan**

- Great **usability** & **accessibility**
- Strong **security** (e.g., Resilient-to-Guessing)
- Not widely **deployable**
- Potential privacy issues

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1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Part 3

7 methods used in 178 current apps

Survey of 139 users, including 49 developers

evaluation criteria for AR/VR authentication

43 methods proposed in 38 prior works
Evaluating proposed methods

- Queried Google Scholar for papers which presented novel authentication mechanisms specifically for AR/VR
- Crawled references of the papers we found to identify more relevant work
- Evaluated each method, relying on papers’ reported results

38 papers
43 mechanisms
Proposed knowledge-based methods

1. Spoken, obfuscated PIN (Cheng et al., 2017)
2. Swipe pattern (Olade et al., 2020)
3. Environment-based PIN (Funk et al., 2019)
4. Cube PIN (Yu et al., 2016)

- Good **deployability** (e.g., Platform-Agnostic)
- Improved **security** (e.g., Resilient-to-Observation)

- Improved **usability**; still poor

1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Proposed physical/behavioral biometrics

5. Sound conduction (Schneegass et al., 2016)

6. Muscle stimulation (Chen et al., 2021)

7. Head movement (Li et al., 2016)

8. Moving virtual balls (Olade et al., 2020)

[Physical]
Usable & accessible

[Behavioral]
Less usable, less accessible

Not deployable
(e.g., not Platform-Agnostic)

Need improved accuracy

1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Proposed multi-factor methods

9. Rubik’s Cube PIN + controller biometrics 
   *(Mathis et al., 2020)*

10. Security questions + head movement biometrics 
    *(Yi et al., 2016)*

- Best **security**!
- Quasi-**Platform-Agnostic**
- Security reduced on other platforms

1. User & developer survey
2. Auth. in current apps
3. Auth. in academic literature
Future directions

Focus on **deployability**

Strengthen **biometrics**: accuracy, privacy, and platform support

Unify the authentication stack with **federated login**

**Password managers** for AR and VR devices
SoK: Authentication in Augmented and Virtual Reality

- Created user- & developer-desired properties for any AR/VR authentication method
- Evaluated the authentication methods currently on AR/VR
- Evaluated proposed AR/VR authentication methods