

# MBBS: A MULTIMODAL BEHAVIORAL BIOMETRIC SHEME FOR SMARTPHONE USER AUTHENTICATION

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SFSCON, 2023

10-11/11/2023

# PRESENTATION OVERVIEW

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- 1 Motivation and problem statement
- 2 Existing authentication solutions and their limitations
- 3 MBBS
- 4 Conclusions

# MOTIVATION

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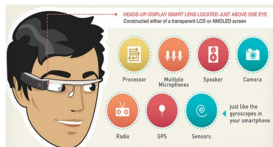
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- 61% of people own a smart device<sup>1</sup>.
- By 2025, 72% of all internet users will solely use smart devices to access the web<sup>2</sup>



<sup>1</sup> OMD, Global (Australia, Belgium, China, Greece, Ireland, Italy, KSA, Netherlands, Spain, Sweden, U.K., U.S.), Retail Revolution, Online Respondents n=11582, Sept.–Nov. 2019.

<sup>2</sup> <https://www.bankmycell.com/blog/how-many-phones-are-in-the-world>

# SMARTPHONES: PERSONAL, CONNECTED AND POWERFUL DEVICES

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- **Smartphones are extremely popular**
  - Any-time any-where computing
  - Powerful processors, long-lasting batteries, GPS, Wi-Fi, etc.
  - Easy to use interface
- **Used in short but frequent sessions (upto 150 times a day (accessed every 6.5 minutes))**
- **Result**
  - **Global smartphone users increased by 49.89% in 2017-2022<sup>3</sup>**
  - **The UK is now a smartphone society<sup>4</sup>**
  - **Computer usage falls as 20% of millennials go mobile-only<sup>5</sup>**

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<sup>3</sup><https://www.bankmycell.com/blog/how-many-phones-are-in-the-world>

<sup>4</sup><https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2015/cmr-uk-2015>

<sup>5</sup><https://www.extremetech.com/computing/226867-comscore-computer-usage-falls-as-20-of-millennials-go-mobile-only>

# SMARTPHONES USAGE

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- **Beyond just classical communication**
  - **Taking pictures & making movies and sharing with others**
  - **Social Networking**
    - **Facebook, Viber, WhatsApp, Skype, Twitter, etc.**
  - **Online Transactions**
    - **Google Wallet, Paypal, XOOM, etc.**
  - **Smartphones continuously tracks the user location and have full control over user's personal data, i.e., emails, transactions details, etc.**
  - **All of these apps generate and store very personal user information which needs to be protected**

# EXISTING APPROACHES

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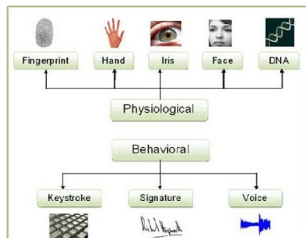
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EVALUATION

CONCLUSIONS

- **What is Authentication?**
  - *Being able to prove a user is who she claims to be*

- **Knowledge-Based**
  - PIN/Password
  - Graphical unlock patterns
- **Characteristic-Based**
  - **Physical**
    - Face, Fingerprint
    - IRIS, Lips, Ear
  - **Behavioral**
    - Key/Touch stroke
    - Voice, Signature
    - Motion-based



# PROBLEMS WITH PINs/PASSWORD

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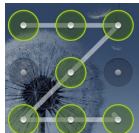
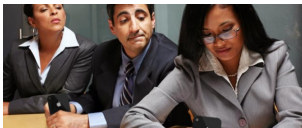
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CONCLUSIONS

- PINs/Passwords
  - Non Transparent
  - Shared/Forgotten
  - Attack Vulnerability



**User consider them annoying<sup>a</sup> and don't use them<sup>b</sup>**

<sup>a</sup>Jakobsson et al. "Implicit authentication for mobile devices." Proceedings of the 4<sup>th</sup> USENIX conference on Hot topics in security. USENIX Association, 2009.

<sup>b</sup><https://www.sophos.com/en-us/press-office/press-releases/2011/08/67-percent-of-consumers-do-not-have-password-protection-on-their-mobile-phones.aspx>

No	PIN	Freq
1	1234	10.713%
2	1111	6.016%
3	0000	1.881%
4	1212	1.197%
5	7777	0.745%

# PROBLEMS WITH PHYSICAL BIOMETRICS

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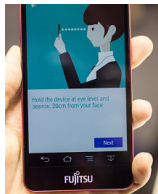
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CONCLUSIONS

- **Physical Biometrics**
  - **Non Transparent**
  - **Environmental Effects**
  - **Attacks Vulnerability**
- **Time Consuming (15-20s)<sup>a</sup>**



- **Apple's iPhone 5S and iPhone 6 fingerprint sensors were hacked**



<sup>a</sup><http://www.ibtimes.co.uk/unlocking-phone-your-eyes-fujitsu-iris-recognition-tech-coming-smartphones-2015-1490297>

De Luca et al. "I Feel Like I'm Taking Selfies All Day!: Towards Understanding Biometric Authentication on Smartphones." Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. ACM, 2015.



# BEHAVIORAL BIOMETRICS

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- There are wide range of actions “**behaviors**” people perform by employing **different strategies, different styles**, and by applying their **unique skills**.
- Many of these behaviors are already used as **behavioral biometrics**, however they are new for smartphone user authentication.
  - **Unobtrusive data collection**
  - **No need of additional hardware**
  - **Arguably very secure**



Barack Obama



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# A Multimodal Behavioral Biometric Scheme for Smartphone User Authentication (*MBBS*)

# MBBS INTRODUCTION

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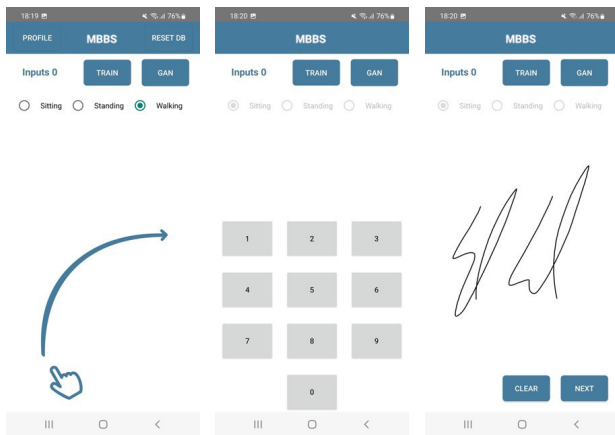
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- User Friendly
- No additional hardware required



# SMARTPHONE SENSORS

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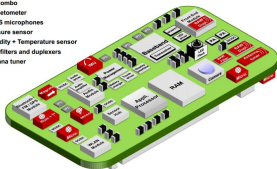
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CONCLUSIONS

- Accelerometer
  - accelerations in 3 dimensions
- Gravity
  - gravity forces in 3 dimensions
- Magnetometer
  - Strength and direction of magnetic field in 3 dimensions
- Touchscreen
- **MBBS utilizes the existing hardware**

- IMU combo
- Magnetometer
- MEMS microphones
- Pressure sensor
- Humidity + Temperature sensor
- SAW filters and duplexers
- Antenna tuner



# VALIDATION

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- **Data Collection**

- 10 training samples in each activity (**total 30**) and 10 testing samples irrespective of activity)
- 3 activities (**sitting, standing, walking**)



- **20 participants (12 male), all of them Masters/PhD students, Samsung Galaxy S21**

# VALIDATION

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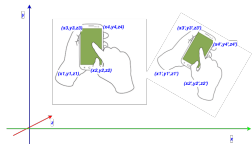
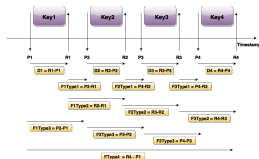
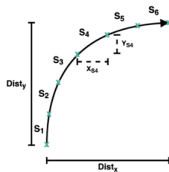
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- Feature Extraction



- **Statistical Features (41, 30, 13, and 63 features for Swipe, Touch-type, Signature, and Phone-hold behaviors, respectively).**

# MBBS APPROACH

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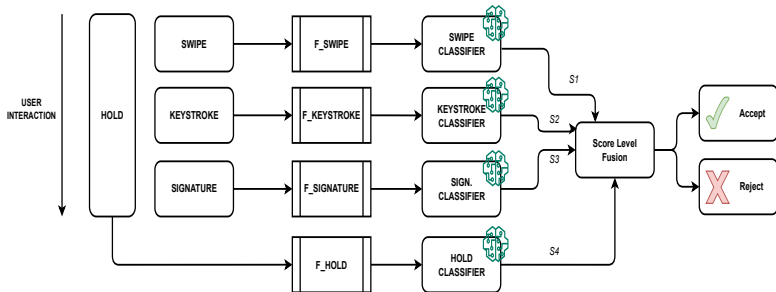
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- Statistical Features
- Score level fusion
- Random Forest classifier as a Verifier



# MBBS GAN INTRODUCTION

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- **Keras Tuner for # of layers, neuron, and best learning rate**
- **We ended up in the development of a 4-hidden-layered generator comprising just 128, 16, 16, 8, respectively and 5-hidden layered discriminator comprising 32, 160, 192, 64, 256 neurons, respectively.**



# MBBS EVALUATION STRATEGY

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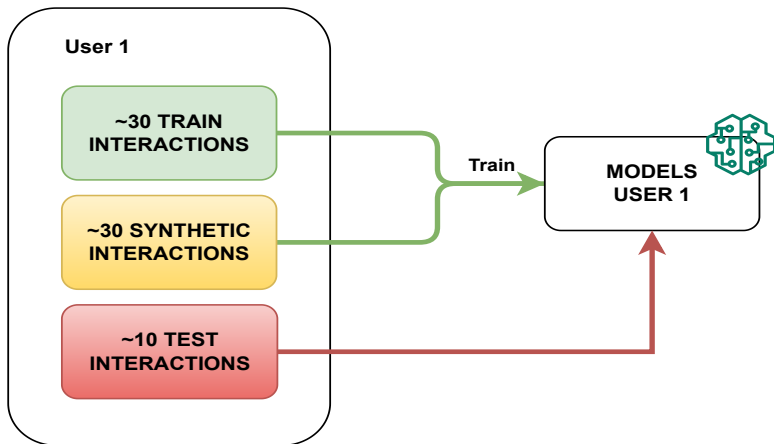
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# MBBS EVALUATION STRATEGY

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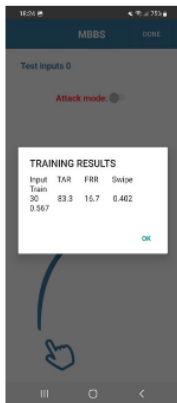
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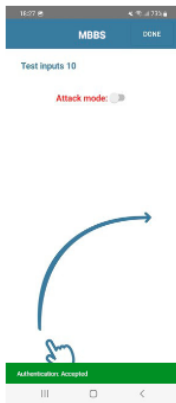
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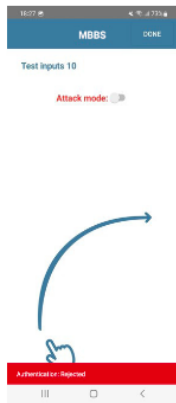
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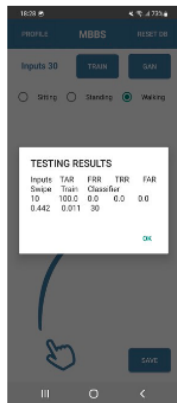
(a)



(b)



(c)



(d)

# RESULTS

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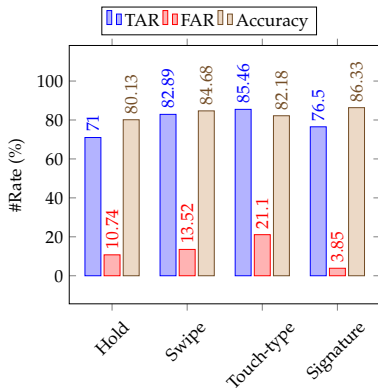
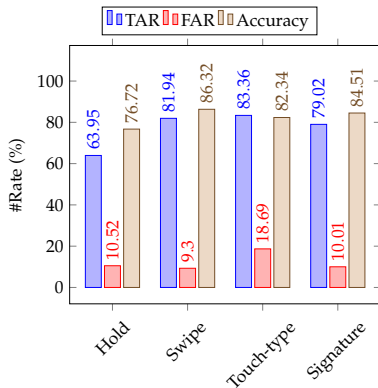
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	TAR (%)	FAR (%)	Accuracy (%)
Original	91.27	5.35	92.96
Augmented	92.87	6.32	93.27

# MBBS: CONCLUSIONS & WAY FORWARD

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- **Conclusions**
  - We demonstrate a GAN-powered user-friendly, secure, and accurate smartphone user authentication scheme, namely *MBBS*
  - We show that user-provided 30 samples are enough
  - *MBBS* is hardware-friendly, is quick, and requires little time to generate synthetic samples
- **Way Forward**
  - More testers and in-the-wild testing
  - cross-vendor testing