

Statistical Meta-Analysis of Presentation Attacks for Secure Multibiometric Systems

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Abstract—Prior work has shown that multibiometric systems are vulnerable to presentation attacks, assuming that their matching score distribution is identical to that of genuine users, without fabricating any fake trait. We have recently shown that this assumption is not representative of current fingerprint and face presentation attacks, leading one to overestimate the vulnerability of multibiometric systems, and to design less effective fusion rules. In this paper, we overcome these limitations by proposing a statistical meta-model of face and fingerprint presentation attacks that characterizes a wider family of fake score distributions, including distributions of known and, potentially, unknown attacks. This allows us to perform a thorough security evaluation of multibiometric systems against presentation attacks, quantifying how their vulnerability may vary also under attacks that are different from those considered during design, through an uncertainty analysis. We empirically show that our approach can reliably predict the performance of multibiometric systems even under never-before-seen face and fingerprint presentation attacks, and that the secure fusion rules designed using our approach can exhibit an improved trade-off between the performance in the absence and in the presence of attack. We finally argue that our method can be extended to other biometrics besides faces and fingerprints.

Index Terms—statistical meta-analysis, uncertainty analysis, presentation attacks, security evaluation, secure multibiometric fusion

1 INTRODUCTION

THE widespread use of biometric identity recognition systems is severely limited by security threats arising from several kinds of potential attacks [1]–[3]. In particular, the use of fake biometric traits (e.g., gummy fingers [4]), also known as “direct”, “spoofing” or “presentation” attacks [1], [2], [5]–[7], has the greatest practical relevance as it does not require advanced technical skills. Accordingly, the potential number of attackers is very large. Vulnerability to presentation attacks has been studied mostly for unimodal fingerprint and face recognition systems [4], [8]–[10]. Multibiometric systems have been considered intrinsically more secure, instead, based on the intuition that an attacker should spoof all the biometric traits to successfully impersonate the targeted client [11], [12].

This claim has been questioned in subsequent work, showing that an attacker may successfully spoof a multibiometric system even if only one (or a subset) of the combined traits is counterfeited, if the fusion rule is not designed by taking that into account [13]–[15]. From a computer security perspective, this is not surprising: it is well-known that the security of a system relies the most on the security of its weakest link [16]. This vulnerability of multibiometric fusion has been shown under the assumption that the fake score distribution at the output of the attacked matcher is

identical to that of genuine users, without fabricating any fake trait. Under the same assumption, more secure fusion rules against presentation attacks have also been proposed.

In our recent work, through an extensive experimental analysis, we have shown that the aforementioned assumption is not representative of current face and fingerprint presentation attacks [17]–[19]. In fact, their fake score distributions do not only rarely match those of genuine users, but they can also be very different, depending on the technique, materials, and source images used to fabricate the presentation attack; i.e., presentation attacks can have a different impact on the output of the targeted matcher. For these reasons, the methodology proposed in [13]–[15] may not only provide an overly-pessimistic security evaluation of multibiometric systems to presentation attacks, but also lead one to design secure fusion rules that exhibit a too pessimistic trade-off between the performance in the absence of attack and that under attack.

To perform a more complete analysis of the security of multibiometric systems, as shown in [17]–[21], considering only one or a few known attacks is not sufficient. One should thus face the cumbersome and time-consuming task of collecting or fabricating a large, representative set of presentation attacks (with different impact on the attacked matchers) for each biometric characteristic, and evaluate their subsequent effect on the fusion rule and on system security. However, even in this case, one may not be able to understand how multibiometric systems may behave under scenarios that are different from those considered during design, including presentation attacks fabricated with novel materials or techniques, that may produce different, *never-before-seen* fake score distributions at the matchers’ output.

In this paper, we propose a methodology for evaluating the security of multibiometric systems to presentation at-

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Statistical Meta Information Systems

Nadia Bianchi-Berthouze



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Metadata Management in Statistical Information Processing Karl A. Froeschl,2013-12-21 As the integration of statistical data collected in various subject matter domains becomes more and more important in several socio economic etc investigation areas the management of so called metadata a formal digital processing of information about data gains tremendously increasing relevance Unlike current information technologies e g database systems computer networks facilitating merely the technical side of data collation a coherent integration of empirical data still remains cumbersome and thus rather costly very often because of a lack of powerful semantic data models capturing the very meaning and structure of statistical data sets Recognizing this deficiency Metadata Management proposes a general framework for the computer aided integration and harmonization of distributed heterogeneous statistical data sources aiming at a truly comprehensive statistical meta information system

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Table of Contents Statistical Meta Information Systems

1. Understanding the eBook Statistical Meta Information Systems
 - The Rise of Digital Reading Statistical Meta Information Systems
 - Advantages of eBooks Over Traditional Books
2. Identifying Statistical Meta Information Systems
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Statistical Meta Information Systems
 - User-Friendly Interface
4. Exploring eBook Recommendations from Statistical Meta Information Systems
 - Personalized Recommendations
 - Statistical Meta Information Systems User Reviews and Ratings
 - Statistical Meta Information Systems and Bestseller Lists
5. Accessing Statistical Meta Information Systems Free and Paid eBooks
 - Statistical Meta Information Systems Public Domain eBooks
 - Statistical Meta Information Systems eBook Subscription Services
 - Statistical Meta Information Systems Budget-Friendly Options
6. Navigating Statistical Meta Information Systems eBook Formats
 - ePub, PDF, MOBI, and More
 - Statistical Meta Information Systems Compatibility with Devices
 - Statistical Meta Information Systems Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Statistical Meta Information Systems
 - Highlighting and Note-Taking Statistical Meta Information Systems
 - Interactive Elements Statistical Meta Information Systems
8. Staying Engaged with Statistical Meta Information Systems

- Joining Online Reading Communities
- Participating in Virtual Book Clubs
- Following Authors and Publishers Statistical Meta Information Systems
- 9. Balancing eBooks and Physical Books Statistical Meta Information Systems
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Statistical Meta Information Systems
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Statistical Meta Information Systems
 - Setting Reading Goals Statistical Meta Information Systems
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Statistical Meta Information Systems
 - Fact-Checking eBook Content of Statistical Meta Information Systems
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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