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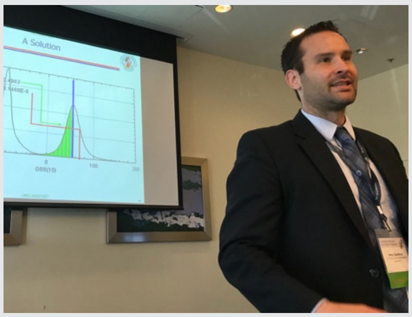
**IN-BRIEF**

# IPTES 2018 Workshop: Statistical Interpretation Software for Friction Ridge Skin Impressions (FRStat)



**"As a community, we are moving towards stronger scientific foundations for fingerprint evidence. FRStat is a step in that direction."**

—Henry Swofford
*Chief, Latent Print Branch at the Defense Forensic Science Center*

## Introduction

The Forensic Technology Center of Excellence (FTCoE), led by RTI International, is supported by a cooperative agreement with the National Institute of Justice (NIJ), award 2016-MU-BX-K110. The FTCoE supports the implementation of new forensic technology and best practices by end users, bridging the gap between the scientific and justice communities. One way the FTCoE accomplishes its mission is through hosting national meetings that bring together professionals spanning several areas of expertise.

The FTCoE hosted the Impression, Pattern and Trace Evidence Symposium (IPTES) on January 22–25, 2018 in Arlington, Virginia. This symposium brought together more than 600 practitioners and researchers to enhance information-sharing and promote collaboration among the law enforcement, legal, and impression, pattern, and trace evidence communities. Participants were able to engage in a variety of content, including keynote addresses, panel discussions, and poster and scientific sessions.

Prior to these general plenary sessions, the FTCoE hosted 13 interactive workshops spanning several topics, including firearm and tool mark examinations, probabilities and likelihood ratios in pattern evidence, and applied polarized light microscopy. This in-brief report highlights the Statistical Interpretation Software for Friction Ridge Skin Impressions (FRStat) workshop, which provided an overview of the software and guided participants through hands-on exercises.

## Objectives

- ► Provide an overview of the FRStat software, including its development, validation, use, interpretation, and limitations.
- ► Educate forensic scientists on the basics of probability and statistics that form the foundation of FRStat.
- ► Guide participants through examples to better understand how to use FRStat, how to interpret its output, and how to appropriately present the results obtained in reports or testimony.
- ► Provide suggestions on the implementation of FRStat in forensic laboratories, including recommendations for policies and procedures.

## Overview

### Purpose

The Defense Forensic Science Center (DFSC) developed FRStat in response to criticisms from legal and scientific commentators on the lack of an empirically demonstrable basis to substantiate conclusions in pattern evidence. This tool is intended to provide a statistical estimate of the strength of evidence to be used in conjunction with the examiner's own conclusion.

This 4-hour workshop began with a review of basic statistical concepts, such as the difference between descriptive and inferential statistics, how to build histograms, and how to calculate probabilities within a distribution. The workshop then described how these concepts were applied in the development of the FRStat software. It went on to discuss the interpretation and reporting of FRStat results and to describe the performance and validation testing that was done on the software. Finally, it presented the limitations of the software, considerations for policies and procedures around its use, and suggestions on how to implement it in attendees' home laboratories.

### About the Instructors

This workshop was instructed by Henry Swofford and Thomas Wortman of the Latent Print Branch at the DFSC. The instructors are both active in the latent print community, frequently presenting on multiple topics to help move the friction ridge discipline towards a stronger empirical foundation.

## Summary of Workshop Material

### Information Provided by FRStat

FRStat detects the locations and angles of friction ridge skin features that have been annotated on both unknown and known impressions by the examiner. It measures the similarity between these two sets of configurations and calculates a "global similarity test statistic" (GSS(t); i.e., a similarity score). This test statistic is then compared to distributions of similarity scores for known same source and different source impressions with the same number of features, and four values are presented as output:

1) The GSS(t), which is meaningless without the context provided by 2) and 3);
2) The probability of observing a GSS value equal to or <u>less than</u> the GSS(t) for two impressions with the same number of features annotated and known to come from the <u>same source</u>;
3) The probability observing a GSS value equal to or <u>greater than</u> the GSS(t) for two impressions with the same number of features annotated and known to have come from <u>different sources</u>; and
4) The probability ratio value, calculated by dividing the value given in 2) by the value given in 3).

The value provided in 4) is the number that will be reported and is a measure of the strength of the evidence. This value is not the likelihood ratio that is frequently invoked in Bayesian reasoning to answer the question, "How much more likely would it be to see these features in agreement if the two impressions were made by the same source, rather than different sources?" Because FRStat considers the amount of similarity between two impressions, and not the specific configurations in agreement with respect to same source and different source distributions, it can only be used to support the analyst's conclusions, not to predict the probability that a particular individual made a particular impression. In essence, FRStat considers how often you would expect to see this many features in this much agreement, not how often you would expect to see these particular features in agreement under the same source versus the different source propositions.

This result is reported by the DFSC as, "The probability of observing this amount of correspondence is approximately [probability ratio provided in the $4^{th}$ output value] times greater when impressions are made by the same source rather than by different sources."

### Development, Validation, and Performance

At every stage of the development of FRStat, effort was made to reflect, to the extent possible, real-world conditions and ensure that any bias in results was toward conservatism (i.e., any reported strength of evidence was slanted to be *weaker than* its likely true value). Full validation documents are available from the presenters and describe in detail how FRStat was developed, validated, and performance tested, but a few highlights are presented here.

*Sample Selection for Empirical Distributions – Non-Mated Pairs*

To maximize the conservatism of the results, the region of friction ridge skin expected to have the highest similarity scores under any condition of rotation and translation was used. Both delta and core regions were tested, and because the data clearly showed that higher similarity scores were achieved with delta regions, these were used to form the empirical non-mated distribution for the model.

### *Sample Selection for Empirical Distributions – Mated Pairs*

To represent the range of similarity that would realistically be observed between two impressions from the same source and minimize the mean similarity statistic values, impressions were taken of known sources with a flat impression and intentional distortion along 10 different factors (lateral pressure along 8 cardinal directions, and clockwise and counter-clockwise twist). These were compared to the distributions obtained from casework to ensure representativeness to real-world conditions.

### *Accounting for Variable Precision of Human Examiners in Feature Annotation*

Recognizing that examiners do not always mark the same feature in the same precise location, this variability was accounted for in the model. Analysts were asked to independently annotate the same features on multiple occasions and their markings were later overlaid. The variability of the markings on the x- and y-axes and in the angles marked was measured and used to form distributions. An algorithm then uses these distributions to randomly displace the feature locations and angles. This process is repeated iteratively to create a distribution of similarity scores for that configuration of features. The output result is the lower bound of the 99% confidence interval.

### *Method Performance Measures*

Once the model was completed, method performance was tested using multiple data sets of mated and non-mated pairs that had not been used in the model's development. Method performance was evaluated in terms of sensitivity, specificity, and reliability (both within-sample and between-sample variability). Thresholds for use in casework were set according to agency-determined preferences for each measure.

## Limitations and Policy Recommendations

As with any model, FRStat does have some limitations and must be internally validated for use before adoption in a laboratory. Some limitations of the model include the following:

- FRStat results depend on user input (feature selection and annotation)
- FRStat cannot verify the accuracy of feature annotations
- FRStat algorithms account for most distortions due to friction skin, but may not capture *all* sources of extreme distortion, such as substrate, matrix, or photographic effects
- FRStat is not designed to evaluate all aspects of impressions, such as pattern type, feature type, intervening ridge counts, and other discriminating attributes considered by examiners

In addition to being familiar with the limitations of the model, agencies considering implementing FRStat in their casework should also consider implementing appropriate policies and procedures for its use. Some that are recommended by FRStat's developers are as follows:

- FRStat should be used *after* the expert has annotated the friction skin features which are believed to correspond and after verification
- FRStat should *not* be used on impressions that the analyst is able to visually exclude
- FRStat should be used in accordance with a set of strict policies and procedures to guard against potential cognitive biases in the analysis, detection, and interpretation of features as well as a quality assurance program to verify the accuracy of the annotated features.

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## More Information

FRStat is currently freely available to US-based government forensic laboratories (federal, state, and local). To obtain a copy, contact Henry Swofford directly at henry.j.swofford.civ@mail.mil. If you are interested in learning more about FRStat and its use, sign up for the FTCoE newsletter and keep an eye on your inbox. We are hoping to organize a workshop on this topic later in 2018.

For more information about the 2018 Impression, Pattern and Trace Evidence Symposium (IPTES), visit https://forensiccoe.org/workshop/18-iptes/.

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## Disclaimer

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