National Science Foundation

Graduate Research Internship Program (GRIP) Opportunities at the

Federal Bureau of Investigation (FBI)

As an intelligence-driven and a threat-focused national security organization with both intelligence and law enforcement responsibilities, the mission of the FBI is to protect and defend the United States against terrorist and foreign intelligence threats, to uphold and enforce the criminal laws of the United States, and to provide leadership and criminal justice services to federal, state, municipal, and international agencies and partners.

The heart of the FBI technological enterprise is its Science and Technology Branch (STB). With over 3,900 employees and about 3,700 contractors, STB is the largest branch in the FBI and among its employees are the foremost experts in many technical disciplines. In broad terms, STB scientist and technologists enable the collection and analysis of evidence; provide communications and essential data to local, state, and federal intelligence and law enforcement assets; and attend to the public in a gamut of ways.

STB has three divisions:

1. Criminal Justice Information Systems (CJIS) Division
2. Laboratory Division (LD)
3. Operational Technology Division (OTD)

With about 2,400 FBI employees and 2600 contractors, the **Criminal Justice Information Systems Division** is the largest division in the FBI. Located in Clarksburg, VW, its mission is to equip our law enforcement, national security, and intelligence community partners with the criminal justice information they need to protect the United States while preserving civil liberties. CJIS provides products like: the Next Generation Identification (NGI) system, the National Data Exchange (N-DEx), Law Enforcement Online (LEO) system, the National Crime Information Center (NCIC), the National Instant Criminal Background Check System (NICS), and the Uniform Crime Reporting (UCR) Program. In addition, CJIS staff serves as the main interface with the public by hosting the operations of the FBI's Public Access Line (PAL).

The **Laboratory Division** is probably the best known division in the STB structure. Located in Quantico, VA, the LD has a staff of about 700 FBI employees and 400 contractors. Its mission is to apply scientific capabilities and technical services to the collection, processing, and exploitation of evidence of the FBI and other duly constituted law enforcement and intelligence agencies in support of investigative and intelligence priorities. LD provides services as: biometric analysis (including DNA and latent finger print services); forensic response (including chemical, biological, radiological, & nuclear sciences, crime scene documentation, evidence control, and forensic imaging), scientific analysis (including chemistry, and cryptanalysis and racketeering, firearms and toolmarks), and explosives.

The **Operational Technology Division** is located in Quantico, VA and has a staff of about 800 FBI employees and 700 contractors. Its mission is to deliver technology-based solutions which enable and enhance the FBI's intelligence, national security and law enforcement operations. Among other products, OTD provides the following: audio analytics, batteries & power sources, digital evidence services, encryption, facial recognition, forensic support, radio services, surveillance, tactical operations, video analytics, and wireless technologies.

About FBI GRIP Opportunities:

1. Topic: Feasibility of Reflective Imaging for Biometric Identification, 01.01
Description: The accuracy of automated Facial Recognition (FR) is highly dependent on the quality of compared images. Variances in pose, illumination, and expression (PIE) are commonly cited as contributing factors when images fail to return known matches within searched galleries. Having the ability to match images retrieved from a variety of sources with a high degree of confidence is desired. This project will explore the feasibility of performing automated FR on images captured as reflections from the eyes of photographed human subjects. The study must address existing literature on the topic; identify potential uses cases from a law enforcement perspective; include the design, development, and implementation of an applied research effort; and produce a final report detailing the scientific foundation behind the work.
Location: Clarksburg, WV
Desired disciplines: Computer Science, Information Engineering, Biometrics
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

2. Topic: Human Factors in Facial and Iris Image Capture, 01.02
Description: The ANSI/NIST-ITL 1-2011 standard provides recommendations for facial and iris image capture; however, it does not establish specific guidelines or address human factors involved in these processes. Research and evaluation are needed to provide guidelines to law enforcement agencies based on those recommendations. Topics for analysis include those human controlled factors that affect and may possibly degrade image quality such as image lighting and background. Various image capturing equipment with the capabilities to capture both face and iris images simultaneously will also need analysis in an effort to determine which devices provide capabilities outlined in ANSI/NIST-ITL 1-2011. Information gathered from this analysis should be presented in a user friendly format aimed specifically at the identification and investigative community.
Location: Clarksburg, WV
Desired disciplines: Electrical Engineering, Industrial Engineering, Social Science, and Computer Science
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

3. Topic: Law Enforcement Officer Access to Biometric Tools via Smartphones and Tablets, 01.03
Description: Timely and accurate information is critical for assisting law enforcement officers (LEOs) in making split second identification decisions during hostile situations. Providing LEOs with powerful identification tools on mobile devices, such as smartphones and tablets, is a significant way for assisting LEOs in making those decisions. This project requires the NSF Fellow speaking with LEOs to identify requirements, researching currently available and emerging technologies, and defining a roadmap for delivering a mobile biometric toolset. Biometrics of interest includes fingerprint, face, voice, iris, and handwriting. The project application is the acquisition of biometric data via a smart phone and tablet, the submission of the data to law enforcement data centers, and the receipt and display of the query results on the smartphone and tablet. Areas of research include biometric acquisition devices, data compression techniques for storage and transmission, techniques for authenticating a LEO submitting a query, and the display and review of query results. Two additional areas of interest are how the mobile

biometric capabilities can be vendor agnostic and operate on a cadre of commercially available operating systems (e.g., iOS, Android, Windows, Blackberry); and how query results can be shared simultaneously amongst multiple LEOs.
Location: Clarksburg, WV
Desired disciplines: Computer Science (experience with mobile app development desired)
Anticipated internship duration: 180 days
NSF_GRIP@ic.fbi.gov

4. Topic: Black-Box Validation Study for Firearms Identification, 07.01
Description: The proposed study addresses shortcomings of previously conducted validation studies on firearms identification by including detailed consideration of the influence of subclass characteristics, minimizing the effect of strong marks that may diminish or change following a break-in period, exploring the effect of primers of different hardness, involving a large number of certified Firearms Examiners, and executing the study in a double blind format. It also assesses repeatability and reproducibility of examiner conclusions. The study will address the concerns expressed by National Academy of Science (NAS) as it pertains to the discipline of Firearms identification, which offers individualization conclusions. The NAS committee reported that the problem with the comparative forensic sciences is they have not "been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source."
The reliability study will examine repeatability, sensitivity, and specificity by focusing on:
• Identifying relevant populations (examiners, prints, etc.)
• Randomly select units from populations (practical issues: participation, data access, etc.)
• Including factors as possible sources of variation
• Double-blind
• Incorporating repetition (same examiners/prints)
• Including both true matches & true non-matches
Black box studies have been advocated as one means of strengthening the scientific foundations of the forensic sciences. Being agnostic to process, a black box study acknowledges the discipline's "lack of a precisely defined process", addressing its "accuracy, reliability, and validity" by focusing solely on results. A black box approach is particularly suitable to address these concerns as they apply to Firearms identifications.
Location: Quantico, VA
Desired disciplines: Statistics
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

5. Topic: Concentration of Gamma Hydroxybutyric Acid (GHB) in Human Hair, 07.02
Description: This project seeks to quantify the concentration of gamma hydroxybutyric acid (GHB) in hair of regular GHB users. Using a validated method, this subpopulation study would analyze hair samples as positive controls from known GHB users (associated with physician-prescribed pharmaceutical products such as Xyrem™). The goal is to develop a representative range of GHB concentrations in hair from GHB users and, possibly, dose-response relationships.
Location: Quantico, VA
Desired disciplines: analytical chemistry or analytical toxicology
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

6. Topic: Identification of Human Age-Related Gene Variants, 07.03
Description: This study proposes a longitudinal transcriptome-wide association study in mice or other surrogates for age-related transcript markers that will be used as candidate genes to predict age in

humans. The forensic relevance of this study is to lead eventually to the identification of genetic markers that can indicate the age of a subject in the absence of a biometric match for identification. The objective of this study is to identify potential genetic markers in humans that indicate the age of the person to further study.
Location: Quantico, VA
Desired disciplines: Molecular Biology
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

7. Topic: Novel Solvents for Forensic Examinations, 07.04
Description: The recent advancements of novel solvents such as ionic liquids may provide enhancements for extraction processes for common forensic examinations. Complex matrices such as paper, hair and blood often require laborious techniques for chemical, toxicological, or genetic analyses. The new solvents now available may enable better methodologies for process improvement both in time, cost and detection limit. The objective of this project is to evaluate a range of novel solvents for suitability in extracting target analytes or biomolecules from evidence of various types.
Location: Quantico, VA
Desired disciplines: Analytical Chemistry, Biochemistry, Toxicology, or Related Disciplines
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

8. Topic: Ecological Niche Modeling / Species Distribution Modeling, 07.05
Description: A variety of techniques have been developed to predict the geographic suitability for a variety of organisms. The application of these techniques to the problem of forensic geographic attribution has not been fully evaluated. Often trace forensic material contains items permitting taxonomic identification either morphologically or genetically. The optimal models to represent the geographic significance of taxa for forensic geographic attribution are not yet known. The goal here is develop or improve extant models for predicting the location of origin for trace evidence associated with species based on predictive ecological niche modeling.
Location: Quantico, VA
Desired disciplines: Biogeography, Landscape Ecology, Global Change Research on Species Ranges/Agriculture
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

9. Topic: Soil Geography/GIS, 07.06
Description: Law enforcement agencies often need to identify the geographic origin of trace material such as soil associated with pieces of evidence. The USDA has mapped the soils of the conterminous U.S. in great detail. However the mapped characteristics are seldom observable in traces of soil on items of evidence. To aid in law enforcement search efforts, the best practices for extracting relevant mapped features from the range of data sources (GSSURGO or NSCC pedon database) and optimizing observations to suit characteristics are required. This project seeks to develop an improved understanding of how USDA soil classification schema can be used for forensic purposes at relevant scales.
Location: Quantico, VA
Desired disciplines: Soil Science, Particularly Pedology, Soil Biogeography, Soil Mapping, Geomorphology/Quaternary Geology
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

10. Genetic Individuation of Plants, 07.07
Description: Forensic science has been revolutionized by the development of methods for human individuation by means of Short Tandem Repeat (STR) loci. As individual plants are stationary, there is the potential to exploit plant genetic individuation to link a person or object to a crime scene based on plant genetic evidence. Due to the complexity of plant genetics and variability among taxonomic groups no standard methodologies exist for plant individualization, although methods have been developed and applied to select taxonomic groups. The goal of this project is to develop or adapt a genetics-based method for the identification of specific, individual plant organisms analogous to a biometric identification in humans.
Location: Quantico, VA
Desired disciplines: Plant Systematics, Plant Genetics, Botany
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

11. Heavy Metals Signatures in Plants, 07.08
Description: A key forensic question is the location of origin for trace evidence such as plant material. While plant species can often be identified morphologically or genetically, the location of a specific plant from which the trace evidence originated is much more challenging. This project seeks to develop a method to associate specific plants with their specific growth environment based on heavy metal signatures. Many plants can hyperaccumulate metals from the soil in which they grow. If the soil environment contains distinctive metals signatures, these might be reflected in plant materials such as bark, woody tissue, and leaves. The objective of this study is to develop *de novo* or adapt existing methods for the analysis of trace levels of metals in plants and the surrounding soils along with the supporting analyses necessary to establish a unique relationship between the plant and its growth soil that allows differentiation from the same plant species grown in different soil environments.
Location: Quantico, VA
Desired disciplines: biology, biochemistry, chemistry, other life sciences
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

12. Heavy Metals Signatures in Pollen, 07.09
Description: A key forensic question is the location of origin for trace evidence such as pollen. While pollen, and therefore plant species, can be identified morphologically or perhaps genetically, the location of a specific plant from which the pollen originated is much more challenging. This project seeks to develop a method to associate pollen with specific plants and their specific growth environment based on heavy metal signatures. Many plants can hyperaccumulate metals from the soil in which they grow; if this metals signature is transmitted to its pollen and the soil environment contains distinctive metals signatures, the pollen could be indicative of a specific geographic location. The objective of this study is to develop *de novo* or adapt existing methods for the analysis of trace levels of metals in pollen, plants, and the surrounding soils along with the supporting analyses necessary to establish a unique relationship between the plant and its growth soil that allows differentiation from the same plant species grown in different soil environments.
Location: Quantico, VA
Desired disciplines: biology, biochemistry, chemistry, other life sciences
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

13. Topic: NEXT GEN Mobile OS – A study to Predict the Direction and Impact of NextGen Mobile OS, 18.01
Description: The next generation of mobile innovation will focus on capturing and modeling consumers' contextual situations. Drawing from users' three main environments—physical, virtual, and social—such

information will become the primary resource for predictive mobile applications and services that will dramatically enhance mobile capabilities and enable devices to become true digital assistants.
We are now entering a new, dynamic phase of mobile technology where there is a shift from a limited set of communication and computing functions to intellectual analysis and rationalization of device owners' physical, virtual and social environments. Soon, mobile devices will analyze and anticipate human needs using platforms that engage the user based on data pulled from multiple sources to create ever more intuitive mobile experiences. We are interested in understanding what advances in NexGen mobile OS might be and how the user experience is likely to change with advances in next-generation mobile technologies.
Contextual intelligence in mobile computing will draw situational information from three main sources, including:
1. Device environment (e.g., available power, operating system, storage, etc.)
2. Physical environment (location, weather, etc.)
3. User environment (ID, applications, stored data, etc.)

Capabilities needed for the next generation of mobile devices, networks, applications and services to collect and process users' data from sources such as device sensors, wearable computers and an electronic ecosystem of transponders on other people and objects. These capabilities include:
a) Location and navigation
b) Device sensors and user interfaces
c) ID and security technology
d) Next-generation networks and clouds
e) Mobile operating systems

This project seeks answers to questions such as:
• What will be the significance of location and navigation as the leading contextual inputs?
• What will be the role of device sensors and new user interfaces, which will capture information about the user and the user's surroundings?
• How will NexGen networks and computing clouds allow data to be stored and accessed in real time?
• How will contextually focused services affect mobile operating systems?
Location: Quantico, VA
Desired disciplines: Computer Science, Electrical Engineering (understanding of mobile communications and radio theory desired; familiarity with the 3G – 4G and new 5G mobile standards desired)
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

14. Topic: Electromagnetic Energy Absorption, 18.02
Description: Improving the performance of anechoic chambers is desired. Specifically, anechoic chamber absorber is effective at capturing the energy of an electromagnetic wave impinging on the carbon impregnated foam covering the walls and ceiling of the chamber. However, the cones of the absorber are necessarily thick (to absorb the lower frequencies), and the foam is relatively heavy. In addition, it is problematic to adhere the heavy foam absorber to the surface of the anechoic chamber walls and ceilings. Various other materials that absorb electromagnetic energy are heavy, expensive, and/or only work at higher frequencies. Desired are materials and/or techniques for simultaneously absorbing broadband electromagnetic energy in the frequency range from 100MHz - 3GHz, which result in designs that are light weight, thin, and absorb energy across the frequency range of interest. Such materials/designs would allow for the absorption of unwanted RF transmissions in anechoic chambers.
Location: Quantico, VA
Desired disciplines: computer science
Anticipated internship duration: 90-days to 1-year depending of proposed scope of work
NSF_GRIP@ic.fbi.gov

15. Topic: Non-Linear/Time Varying Antenna Design Techniques, 18.03
Description: Most antenna design techniques are based on linear techniques and the standard antenna characterization techniques are based on linear theory. The fundamental limit of size versus performance and frequency is based on a linear time invariant antenna. Exhaustive research into non-linear and time varying techniques in antenna design has yet to be completed. In addition, characterization techniques appropriate for non-linear and time varying techniques need to be developed. The Non-Fosters antenna design technique is one non-linear technique that attempts to discover the equivalent fundamental limits for a non-linear antenna. This and other and other non-linear techniques will be explored in this project.
Location: Quantico, VA
Desired disciplines: Electrical Engineering, Physics
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov

16. Topic: Universal Digital Video Decoder, 18.04
Description: Law enforcement agencies frequently encounter digital video files that have been encoded using proprietary codecs (coder/decoder). These files typically are retrieved from digital video recorders (DVRs) in commercial establishments, and they can often provide crucial evidence in a criminal investigation, such as in the 2013 Boston Marathon Bombing investigation. Although an appropriate player or codec are often recovered at the same time that the digital video file is recovered, it often happens that this is not the case, so officials are left with a video file, but no way to view the contents. In such cases, officials will typically attempt to acquire the appropriate player or codec from the commercial entity responsible for manufacturing the DVR. Unfortunately, this process can prove to be time-consuming, or even impossible (e.g., if the manufacturer is overseas or has gone out of business). In other cases, the player or codec only allows for the export of video data in a re-compressed or trans-coded format with reduced resolution or that lacks metadata that was attached in the original format (e.g., camera information that is encountered in multi-camera systems).
Up to now, agencies and contractors have addressed this problem by building libraries of players and decoders, to include players that have been reverse-engineered from detailed research of individual players. In some cases, agencies and their contractors have built systems that scan digital video files to detect known file structures to identify the existing player or codec that corresponds to the given video file. This requires pre-knowledge of the proprietary format. There is no solution yet to solve the "unknown video file problem."
The research problem identified herein is effectively a problem of "universal" decryption, but with the benefit that it is focused on video files, which, given the nature of the data in question, *should* have some redundancy that could be exploited. In particular, digital video files should have multiple frames that repeat at some given interval, with a consistent size, bit-depth, etc. It is hoped that an approach to decrypting unknown video files can be investigated and a solution developed so that the raw image data can be extracted in the absence of a proprietary solution. An extension of this problem would be to investigate how the related metadata for each set of frames can be extracted and reassembled along with the image data.
Location: Quantico, VA
Desired disciplines: Electrical Engineering, Mathematics (Cryptanalysis), and Computer Science
Anticipated internship duration: 4-month to 1-year based on specifics of contribution
NSF_GRIP@ic.fbi.gov

17. Topic: Facial Feature Frequency and Persistence with Aging, 18.05
Description: Forensic identification of human beings from facial images (for use in court or for intelligence purposes) relies upon manual comparison of questioned and known images. Forensic experts compare physical features such as the eyes, ears, nose, mouth, and facial lines and marks (freckles, moles, scars, etc.) and assess the significance of similarities and differences before reaching a

determination regarding identification or exclusion. (For a complete list of these features, visit www.fiswg.org). Unlike forensic DNA analysis - which has a well-understood, biologically-constrained set of potential outcomes (with statistical significance) – there is no comparable known set of biological constraints on the range of facial features, lines, and marks that could be used to define a "match" or "no-match" to some degree of statistical certainty. As a result, forensic examiners must consider the variability of these features over time (e.g., expected increase in wrinkles with time or decrease in visibility of freckles with lack of sun exposure) and use their judgment before reaching an opinion-based conclusion. There is a strong impetus to replace such opinion-based approaches across all forensic sciences.

Computer-aided ("automated") facial recognition techniques are pattern-based approaches that do not rely upon any underlying physical theory related to the frequency of facial features, or their persistence over time. At their best, automated facial recognition algorithms provide similarity scores between the two samples, but there is no underlying physical basis for defining the true statistical significance of such similarities or differences. (It should be noted that photo-anthropometric approaches to facial identification using landmark distribution have been shown to be unreliable and thus not worthy of further research.)

Fundamental research needs to be performed to document the frequency of given facial feature shapes, lines, and/or marks across a variety of population groups, as well as the persistence of these over time. In particular, the persistence of freckle and mole (i.e., nevi) patterns over long periods of time from childhood to senescence is not known to have been documented in the literature, although there may be pieces available in dermatological journals. A survey of such literature would be a valuable addition to the forensic literature.

Location: Quantico, VA

Desired disciplines: Anthropology, Biometrics, Computer Vision, Computer Science, and Gerontology

Anticipated internship duration: 4-month to 1-year based on specifics of contribution

NSF_GRIP@ic.fbi.gov

18. Topic: Social Impacts from Deployment of 3D Printing Technology, 18.06

Description: 3D printing is a process of making a three-dimensional solid object of virtually any shape from a digital model. 3D printing is achieved using an additive process, where successive layers of material are laid down in different shapes. Additive manufacturing takes virtual models (3D blueprints) from computer aided design (CAD) or animation modeling software and "slices" them into digital cross-sections for the machine to successively use as a guideline for printing.

To perform a print, the machine reads the design from a file and lays down successive layers of liquid, powder, paper or sheet material to build the model from a series of cross sections. These layers, which correspond to the virtual cross sections from the CAD model, are joined or automatically fused to create the final shape. The primary advantage of this technique is its ability to create almost any shape or geometric feature, one at a time.

Several projects and companies are making efforts to develop affordable 3D printers for home desktop use. Three-dimensional printing makes it as cheap to create single items as it is to produce thousands and thus undermines the economies of scale principal Rapid Manufacturing, Mass Customization, Prototype Development, Design Experimentation, etc are only a few new impacts that 3D Printing will bring to society.

This Project will identify the current and future applications for 3D Printing and document the 'game changing' impacts on society. How will 3D Printing evolve and impact the production of physical objects? What impacts will that have on 'our way of life'? How might 3D Printing impact creativity and innovation? What are the significant areas that will be most impacted by 3D Printing? What expected new materials will be used with 3D Printing? And finally, where is 3D Printing Technology headed? What 3D Printing innovations can be projected within the next 2 – 5 years?

Location: Quantico, VA

Desired disciplines: Economics, Sociology (some general engineering understanding of the diversity of 3D printing applications is desired)
Anticipated internship duration: 1-year
NSF_GRIP@ic.fbi.gov