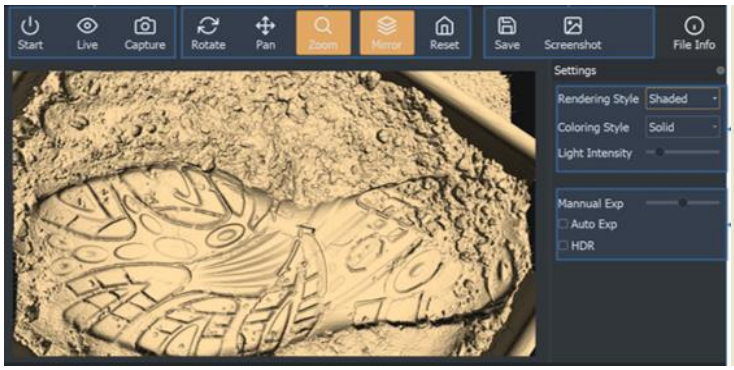
Moving Knowledge from Research to Impact

SUCCESS STORY

National Institute of Justice (NIJ) and Purdue University

Advancing 3D Imaging for Footwear and Tire Impressions



"Purdue's 3D scanner promises to be a game changer as it allows the fast collection of the 3D detail of impressions with minimal training."

—James Wolfe
Alaska State Crime Laboratory, retired

Problem and Solution Synopses

Shoeprints and tire tracks are common types of impression evidence found at crime scenes. They can be used to evidentially link a suspect to the crime and generate important investigative leads in a case. When a shoe or tire impacts a deformable substrate like soil or snow, it can leave a three-dimensional (3D) reproduction of its tread surfaces that are currently recovered by crime scene investigators (CSIs) using two-dimensional photography and casting techniques. However, the quality of the evidence is often limited by the CSI's skill level, the quality of their equipment, and their available supplies and time.

The current 2D photography technique uses traditional camera equipment set up specifically to capture the detail and physical size attributes of the impression; it is challenging and time-consuming to execute, even for the most skilled CSI. Available casting methods (e.g., dental stone and sulfur cement) require specific supplies and equipment and practice to properly execute. The substrate conditions (e.g., low contrast soil and highly reflective snow) may lead to poor quality evidence. Development of validated 3D imaging technologies for shoe and tire impression evidence is a major research gap outlined by the Footwear and Tire subcommittee of the National Institute of Standards and Technology (NIST) Organization of Scientific Area Committees (OSAC).

Dr. Song Zhang at Purdue University is developing a 3D imaging system to overcome these challenges. This system is based on optical 3D scanning technology and uses a binary defocusing technique and an auto-exposure control method to generate a highly detailed 3D model of the impression (a virtual impression).

The virtual impression will enable lab analysts to conduct a virtual examination of the impression as if they were studying it in situ. The system can also generate a virtual cast by inverting the data in the virtual impression, so examiners can directly compare the shoe outsole or tire tread to the virtual cast on-screen or generate a physical model using a 3D printer. These virtual items of evidence can be manipulated in 3D space by rotating them 360 degrees along any axis.

Key Benefits

- User friendly: hardware automation and intuitive graphical user interface enable ease of use.
- Life size and accurate output: The system accurately captures the physical size attributes of the impression in all 3 dimensions.
- Field portable: The first-generation device will be battery powered and appropriate in size and weight for easy handling in the field, like a 2D camera.
- Time savings and increased collection: One 3D scan takes 10 seconds and negates having to take multiple camera shots followed by casting. This increased efficiency will allow CSIs to capture more impressions.

Disclaimer: *This success story was supported by Award No. 2016-MU-BX-K110, awarded by the National Institute of Justice, Office of Justice Programs, U.S. Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this publication/program/exhibition are those of the author(s) and do not necessarily reflect those of the Department of Justice.*

Published May 2020

More Information

To learn more about the research presented in this success story and partnership opportunities, please contact

Dr. Song Zhang
Purdue University
szhang15@purdue.edu

To learn more about FTCoE and the impact of NIJ research, please contact

Jeri Ropero-Miller, PhD, F-ABFT
Director, FTCoE
RTI International
jerimiller@rti.org

Jonathan McGrath, PhD, MSFS
Senior Policy Analyst, Office of Investigative and Forensic Sciences
National Institute of Justice
jonathan.mcgrath@usdoj.gov

Research Support

The research presented in this success story was supported by NIJ award 2016-DN-BX-0189: Development of a Portable 3D Imaging System for Capturing Shoe and Tire Impressions

Collaborators

Dr. Zhang would like to thank Tyler Bell, Michael Feller, Jae-sang Hyun, Yi-hong Liao, David Baldwin, Ian Bortins, and Jim Wolfe for their work on the project.

Image Credits

Pages 1 and 2: Dr. Song Zhang, Purdue University

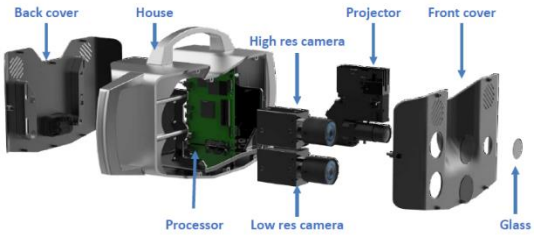
NIJ Research

Dr. Zhang was awarded NIJ grant 2016-DN-BX-0189 to develop a 3D imaging system suitable for capturing exam-quality footwear and tire impressions. Preliminary research demonstrated that his approach using camera-pixel-resolution 3D imagery capture and precise timing control has the potential to achieve the goal of recording these impressions with sufficient accuracy and resolution in both soil and snow. **Dr. Zhang has two prototype systems currently available for testing and evaluation by the forensic community and seeking partners for real-world testing to improve future development**. He plans to continue to refine his technology and expand its use to capture other forensic evidence, including fingerprints.

Bringing Research to Practice

A prototype system, patent pending, was designed to capture an area of approximately 14" x 10" with a spatial resolution of approximately 140 ppi. The next generation device is expected to improve spatial resolution to 400 ppi. Dr. Zhang's team has demonstrated the device in two workshops, one at the 2018 NIJ/FTCOE Impression, Pattern, and Trace Evidence Symposium and another at the 2018 International Association for Identification (IAI) conference. The system has been extensively tested on mock samples by the Purdue lab, workshop participants, and a team of forensic examiners from the Omaha Police Department. Feedback on the performance and usability of the system from workshop participants and other evaluators has been overwhelmingly positive. Results of the work will be published in the Journal of Forensic Sciences. A recent FTCoE webinar titled *Portable Advanced 3D Imaging for Footwear and Tire Impression Capture* on October 23, 2019, provided an overview of the technology and its benefits.

The Future



Prototype system design

Dr. Zhang recently secured $2M in private funding for commercialization and started a company called VE Optics. NIJ is supporting a second phase of this work under grant 2019-R2-CX-0069: "Development of Dual-Resolution 3D Imaging Device and Software Tools for Shoe and Tire Impression Evidence Collection, Visualization, and Recognition." Future work will address the operational requirements identified by NIJ's Forensic Science Research and Development Technology Working Group and intends to produce a novel instrument, as illustrated above, for tire tread and footwear impression evidence collection, along with software tools for evidence visualization and recognition. The proposed software and hardware systems will improve the "front-end" evidence collection and will lead to the production of a useful instrument and tools for forensic applications.

To learn more about this technology and future products, including borrowing one of the prototypes for testing, please contact Dr. Zhang at Purdue University (szhang15@purdue.edu). Stay informed about other forensic products and services by requesting the Forensic Technology Center of Excellence (FTCoE) e-newsletter (ForensicCOE@rti.org).

NIJ National Institute of Justice
STRENGTHEN SCIENCE. ADVANCE JUSTICE.

Forensic Technology
CENTER OF EXCELLENCE

RTI INTERNATIONAL