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Ryan Tomcik

IAI Liaison to the NIJ

Cadre Forensics: A Successful Case of End-User Involvement

For this interview I invited Dr. Ryan Lilien of Cadre Forensics to highlight his group's NIJ-funded research and successful collaboration with forensic practitioners. His project is titled "3D Topography System for Imaging and Analysis of Striated and Impressed Tool Marks".

Dr. Lilien is formally trained in Computational and Biomedical research (MD/PhD, Dartmouth). Although most of his research lies at the intersection of computer science and biology, the computational aspects of his work involves bringing novel algorithms to bear on interdisciplinary research problems. In applied computer science they are often tasked with making sense of inherently noisy data, identifying patterns, and assessing similarity. These are the same tasks they face in applying computation to forensics.

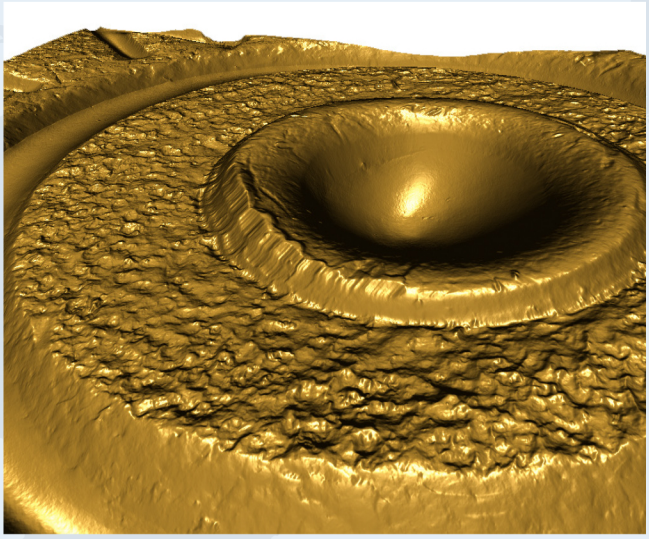
Ryan Tomcik: *Can you describe the operation and some of the novel aspects of your TopMatch-GS 3D scanner operation?*

Ryan Lilien: Because our system is so new, novel aspects keep evolving. At its core, the TopMatch-GS 3D system has imaging hardware capable of rapidly measuring three-dimensional surface topography at micron-resolution and a software component able to efficiently identify similarity in tool marks among these three-dimensional scans. Our 3D imaging hardware is based on the patented GelSight imaging technology. GelSight employs a thin piece of elastomeric gel, which is mostly transparent save for one side, which is painted. When applied to a surface, the painted side of the gel conforms to the surface and removes material-specific effects (such as shininess and specularities), which can otherwise complicate surface measurement.

Once the full three-dimensional scan is in our system, our image-matching algorithms take over. The software identifies unique features in each image and uses these features to compare and correlate two casings. Our detected features roughly correlate to the same type of bumps, corners and ridges identified by a human firearms expert. Unlike previous cross-correlation based methods, which compare the entire surface pixel by pixel, our method compares several thousand of these unique image features between the two images.

What types of toolmark impressions can be processed using your system?

At present we image and algorithmically compare the breech-face impression as it appears on the primer. In 2014 we will be extending our analysis from impressed marks to include striated marks. We will start with analysis and comparison of the aperture shear but will also explore these methods for use with bullets.



Interactive visualization of the aperture shear with TopMatch-GS 3D. Users can rotate, zoom and move a virtual light.

How does your GelSight-based system compare to other 3D imaging technologies?

Being an economical alternative is great, but the area we're most excited about is the matching accuracy. At the AFTE 2013 Albuquerque meeting we presented our early results on casings from real-world 9mm firearms; that is, firearms selected from the Oakland and San Francisco reference collection. These firearms were not selected because they reliably mark casings but rather because they provide the range and quality of marks seen in actual practice. As such, some firearms were extremely subpar in terms of their ability to mark casings. Even still, we saw close to 100% match accuracy with no false-positives across over 30,000 comparisons.

Our system is capable of imaging down to approximately one micron per pixel. This scale is well matched for use in firearm forensics. Using the NIST standard casing as a reference, we determined that most human examiners look

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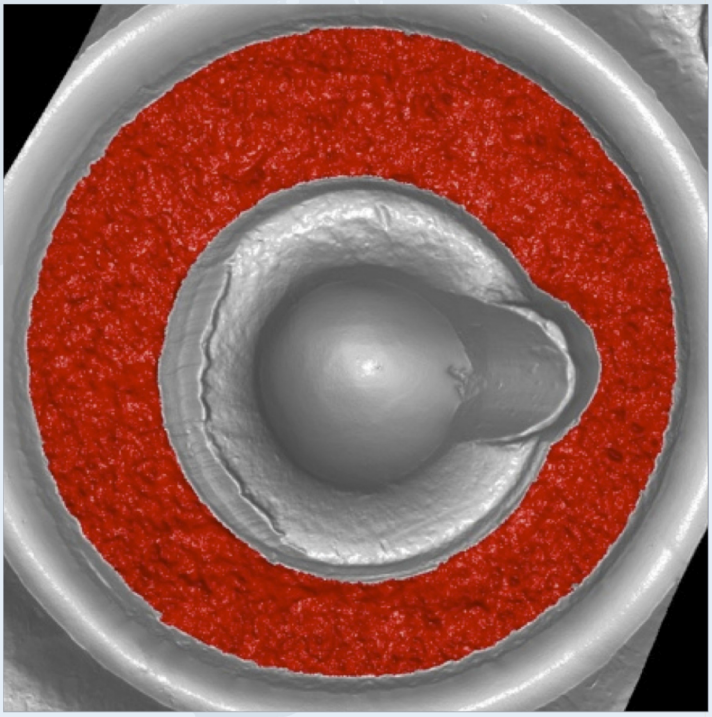
in Firearms R&D

at features between 30 and 100 microns in diameter, occasionally down to 10-20 microns but typically not smaller than that. Our system is able to capture these fine details.



Breech-face impression is highlighted in red by the TopMatch-GS 3D system. This region is currently used to compare casings.

If a 3D image was captured using a different technology, could you compare that image to one captured using GelSight?

The ability to compare scans from different imaging technologies would allow virtually any lab with a 3D topography scanner to exchange data with any other lab. We have actually tested this and the results seem to indicate that yes, our software can indeed compare confocal microscopy-captured surfaces and GelSight-captured surfaces. This idea, what we're terming "cross-modality matching," is part of our new NIJ R&D award that will be underway in 2014. We are also spearheading an effort to establish a common surface topography file format; more information is available on our website. We will be encouraging equipment manufacturers to support this standard, thus facilitating the development of algorithms such as ours.

Can you describe your collaborations with forensic practitioners?

I've often stated that this is the forensic community's system; we're just helping them create it. Therefore, our project benefits greatly from our forensic collaborations. Our main partner is Todd Weller of the Oakland Police Department. Todd has a wealth of expertise both in forensics and technology and is thus an ideal collaborator for a project such as ours. We also rely on partners like Todd to guide development toward solutions that are best suited for the forensic community. For example, our forensic partners have already suggested improvements to the workflow and data organization surrounding casings and incidents (i.e., crime scenes). I'm happy to say that we've already incorporated many of their suggestions into revisions of our TopMatch software.

We have also conducted deployment studies with several state and local labs. For example, one of our deployment studies was with Andy Smith at the San Francisco Police Department, whose group evaluated a very early prototype system. Andy's lab is very interested in evaluating and advancing next generation technologies, so they've been great collaborators.

Technology transfer and commercialization are very important for the forensic science community. Will firearms examiners be able to use this technology in the near future?

We aim to have a commercial product available in early 2014. The system will incorporate all functionality developed and refined through current research efforts. Labs which purchase a system will be eligible for all software updates and added functionality as it becomes available. People interested in commercial availability should contact us.

Who can we contact for more information on this project?

We're always interested in hearing from forensics labs and anyone interested in talking science. People can also join our mailing list to be notified when systems will be commercially available and when our research paper is published. Our main website is **www.CadreResearchLabs.com** and readers can learn more about the TopMatch-GS 3D system directly at **www.CadreForensics.com** or you can email **Forensics@CadreResearch.com**.

Ryan Tomcik