Lucas Sabalka Interview

Conducted by Melinda Lanius

Communicated by Alexander Diaz-Lopez

Lucas Sabalka is at Ocuvera (see www.ocuvera.com).

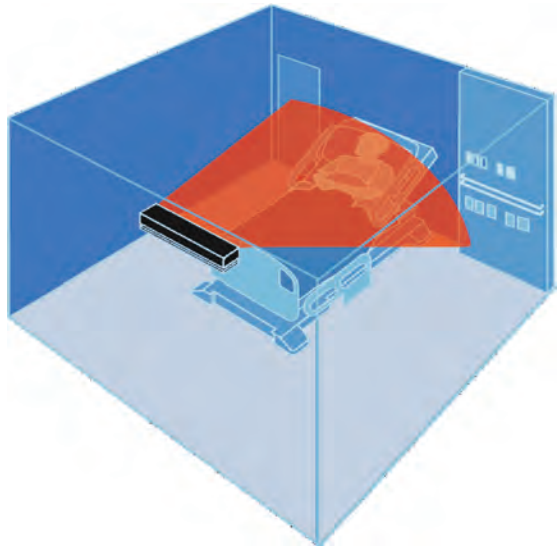
Lanius: *When and how did you know you wanted to be a mathematician?*

Sabalka: I have always been drawn to mathematics and science. I would play with science-based toys and kits and watch shows like *Square One* and *3-2-1 Contact* as a child. When I got to high school, I joined the Math Club, and that clinched my career path. My mentor and the organizer of the Math Club is Bill Rogge, an energetic and passionate mathematics enthusiast, who shared his infectious joy for puzzles, logic, and mathematics, and shaped my view of the beauty of mathematics. I voraciously consumed mathematics, attending the Canada/USA Mathcamp three times in high school, participating in the Penn State Mathematics Advanced Study Semesters as a college sophomore, and completing my undergraduate mathematics requirements in my first three semesters.

Lanius: *Who encouraged or inspired you?*

Sabalka: My path has been most influenced by strong mentors. My mother was always supportive of me and guided me to who I am. My high school teacher, Bill Rogge, was a large influence.

My undergraduate thesis advisors, Susan Hermiller and John Meakin, showed me the appeal of geometric group theory, an intriguing overlap between algebra and topology. Dr. Hermiller especially helped me choose my



The Ocuvera system allows hospitals to automatically detect patient behaviors, such as agitation, that are correlated with increased risk of falling. This image shows a representation of Ocuvera deployed in a hospital room.

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graduate school and career path. I went to the University of Illinois at Urbana-Champaign for my graduate work in order to work with Ilya Kapovich, who was a great advisor. My postdoctoral advisors, Misha Kapovich and Ross Geoghegan, were also encouraging. Dr. Geoghegan helped me navigate the academic job market and supported me in transitioning from academia to industry.

Lanius: *How would you describe your work to a graduate student?*

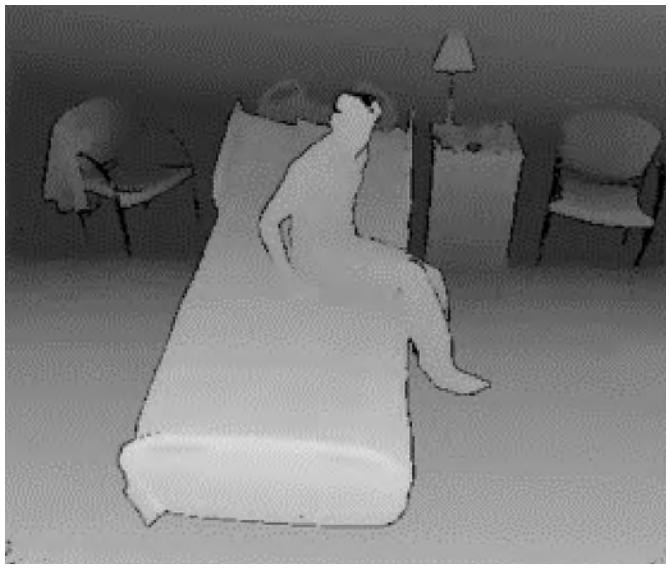
Sabalka: I am currently working on a project called Ocuvera. Ocuvera is a technology-based fall-prevention product for hospitals. Falls are one of the top preventable medical problems today, especially for older adults. Ocuvera attempts to reduce fall risk by using a three-dimensional camera, placed in hospital rooms, to automatically monitor patient behavior. If behavior is detected that is indicative of elevated risk of falling, such as agitation, beginning to get out of bed, or getting out of bed, the system detects this behavior and alerts hospital personnel. Personnel are able to immediately view what is happening in the room, talk to the patient via two-way audio communication, and go to the room to mitigate the cause for the risky behavior.

I am part of a three-person team, with Josh Brown Kramer and Ben Rush, tasked with implementing the computer-vision components of the Ocuvera system. The raw three-dimensional signal comes off the camera as a two-dimensional array of distances. Our job is in part to determine what portion of that signal represents specific objects, such as the floor, a wall, a table, or a hospital bed. This information can change over time if the camera is bumped, a table is moved, or the bed is raised. We monitor the scene for movement and track objects resembling people. Our system can track an arbitrary number of people. We identify which person is the patient, and we monitor that person for signals correlated with elevated risk of falls, such as sitting up or showing agitation. We use many mathematical tools, including geometry, probability theory, statistics, mathematical morphology, image manipulation, decision-forest-based machine learning, convolutional neural networks, and image filtering.

I work on a technology-based fall-prevention product for hospitals.

Lanius: *Do you have a favorite past project you could share with us?*

Sabalka: At Ocuvera, I am most proud of my work on image filtering. We use an affordable, commercially available three-dimensional camera based on the time-of-flight of infrared light from the camera to the scene and back. The raw signal has significant noise, including variance in depth, missing values, and visual artifacts. My colleagues and I observed that the variation is largely predictable for a given pixel over time, so incorporating a time-based element can significantly improve image fidelity. This is useful for both image quality and video compression. The biggest challenge is in smoothing pixels over time but still faithfully representing objects in motion: discerning between motion and noise, handling missing information in the presence of motion, and showing small movements accurately. Creating the real-time algorithm to implement this smoothing has been my favorite project.



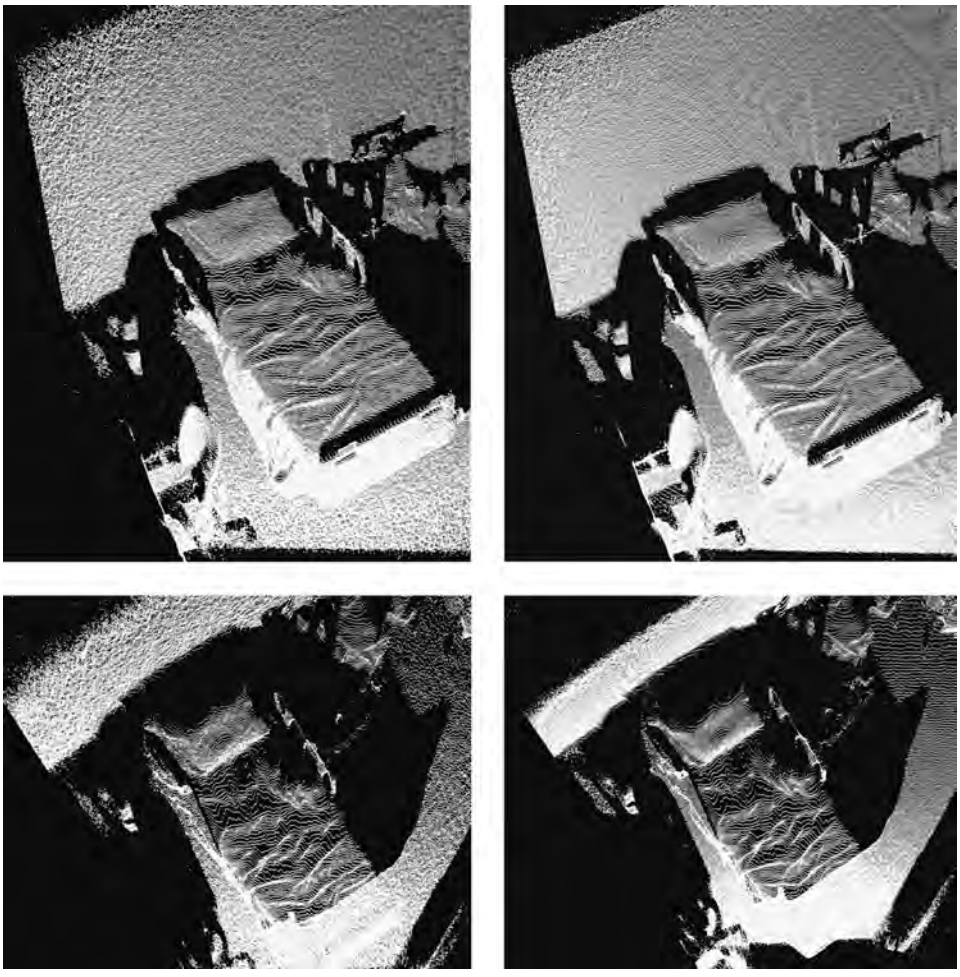
This image shows a visual representation of a depth frame: an array of distances to points in the scene from the plane going through the camera and perpendicular to the focal axis of the camera. Shown here is a typical situation of someone in a hospital setting about to get out of bed.

Lanius: *What is a typical workday like?*

Sabalka: I have a roughly 9-5 job, where by "roughly" I mean I have flexible hours: some days I get in before 8 and stay until after 6; others I'll work 9:30-4:30. I usually start the day by catching up on email and checking on the results of the previous day's test runs: we have a cluster of about 60 computers that calculate our machine-learned algorithms and test our latest improvements. We have a daily ten-minute team meeting that we call "stand up" because the idea is if everyone is standing then they'll be more succinct. We have an open office plan, so many times per day I will be asked to help a colleague with a problem or review a particular piece of code or algorithm, and reciprocally I'll ask for help. Most of my time is spent implementing and testing my various ideas, though a fair bit of time is spent just thinking, in front of my computer or with a piece of paper or at a whiteboard. I am coding probably a bit over half of my day.

Lanius: *What is the work culture like at Ocuvera and Nebraska Global?*

Sabalka: Nebraska Global is an incubator company that helped found Ocuvera, and it is connected to about a dozen small companies with a total of around 75 employees. I have worked with two of these sis-



These two pairs of images show point clouds encoded in a depth frame. Both images are from the same overhead perspective and of the same scene of a bed. The camera captured this data from a position higher than the bed. On the left in each image pair is the unsmoothed frame, that is, the raw data from the camera. On the right in each pair is the smoothed frame, which has been processed to reduce noise and increase fidelity to actual distances: note especially the back wall and floor.

ter companies, but I have always primarily been with Ocuvera. It was started because of the success of EliteForm, a company harnessing three-dimensional cameras in athletic training space. I was brought on to work on Ocuvera for my knowledge of geometry and experience with programming. I have less control over the broad project that I'm working on, but I still largely dictate where my energies are best directed, and I find almost every problem I've been tasked with engaging. I set my hours and pace, and in return I am expected to show reasonable progress towards my goals.

Nebraska Global companies employ a variety of people. My coauthor Josh Brown Kramer was a professor of mathematics and is now a coworker. Our CEO dropped out of high school in the 1980s to found his first very successful tech company. Most employees have a background in software engineering, especially software design. We also have people from a variety of backgrounds who do business development, project management, sales, tech support, human resources, hardware—many roles you would find in a medium-sized company.

Lanius: *How do you balance career and outside interests (e.g. hobbies, family time, vacations)?*

Sabalka: One benefit of my particular job is that it typically stops when I leave work. I may toy with a problem at night, or log a few hours on a weekend, but I find myself largely free for outside interests after 5 pm. Vacation at my work is flexible and not closely tracked, though it's important not to abuse that privilege. Volunteerism is strongly encouraged, including during work hours, so I donate 5-15 hours per week both inside and outside of work hours to charity: I use my speaking skills developed from lecturing to talk to thought leaders and community members about solutions to global warming.

Lanius: *Are there any speed bumps in your journey that you could share with us?*

Sabalka: Choosing to move from academia to industry was a difficult one for me. The transition itself was not nearly as hard as I feared, but making the decision to step into the unknown, after having worked for 14 years to get my tenure-track research position, was intense and personal. My wife and I had many long discussions about what we wanted both near term and long term, what were the risks were, and what the costs and benefits were. Industry is better for me personally. In retrospect, I should have had more confidence in my ability to adapt, but change is scary.

Making the decision to step into the unknown was intense and personal.

Lanius: *What advice do you have for graduate students?*

Sabalka: I chose my graduate school to work with my doctoral advisor, and I'm grateful I did. I highly recommend seeking out someone you work well with. Aside from choosing an advisor, I recommend considering early

what your post-graduation options are. Would you be comfortable in a teaching college? Doing software engineering? Working on Wall Street? Do you handle well the self-driven nature and pressures of research? You do not have to commit to any single career path, but you may want to keep more doors open, especially if one job market tightens before you graduate. Consider choosing an advisor or dissertation topic that opens more options. If you are thinking about industry, try to find an internship over a summer, both to see if it's right for you and to have the experience. If computer programming or financial quantitative analysis are options, you might look at courses in those areas. Even if you aren't considering non-academic jobs, a supporting skill like computer programming can be useful.

A degree in mathematics is a degree in advanced problem solving.

Lanius: *If you could recommend one book to graduate students, what would it be?*

Sabalka: My personal favorite is Hatcher's *Algebraic Topology*. I'm a bit biased here, but I find thinking topologically/geometrically/physically is a vital perspective in many areas.

Lanius: *Any final comments or advice?*

Sabalka: Mathematicians don't just do mathematics. Higher mathematics is about problem solving, logical reasoning, and creative thinking. If you are considering non-academic careers, it is important to gain knowledge or experience to make you competitive, but don't sell yourself short in the job market: a degree in mathematics is a degree in advanced problem solving.

Photo Credits

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Interviewer photo courtesy of Melinda Lanius.

Melinda Lanius

ABOUT THE INTERVIEWER

Melinda Lanius, a Wellesley College graduate, is currently earning her PhD in mathematics at the University of Illinois at Urbana–Champaign.