Could Virtual Reality Tools Transform Poultry Processing Equipment Design?

It’s a safe bet that when someone thinks of virtual reality, their first thought is of the latest video game on the market, not tasks related to poultry processing. But, researchers in the Georgia Tech Research Institute’s (GTRI) Agricultural Technology Research Program are accustomed to finding new applications for existing technologies. One of their latest research endeavors does just that.

The Virtual Reality (VR) project is exploring VR technology as a tool to aid in the design of automated systems for processing natural products. In the poultry industry, this applies to handling, cutting, and deboning operations.

“Current equipment design requires handling and manipulating actual birds in a destructive manner. Each test requires time to set up and perform, and cannot be repeated easily,” explains Sim Harbert, GTRI senior research engineer and project director.

Natural products like bird front halves or whole birds are irregularly shaped and difficult to manipulate. Using VR technology for initial testing and evaluation of automated solutions eliminates the need to use real product or build and test actual hardware.

To begin, researchers tested algorithms for the shoulder cutting task in a VR environment. Using HTC Vive and Samsung Gear VR systems, they were able to visualize and assess the cutting paths based on previously developed algorithms. Harbert says this testing along with further refinements using VR models resulted in the development of new cutting and manipulation approaches.

Genetic Phenotype Testing

Next, the team used VR to better understand and generate models of carcass variations of different genetic phenotypes. The expression of an individual bird’s genotype and interaction with the environment is its phenotype, explains Harbert.

To get representations of bird phenotypes, researchers took computerized tomography (CT) and magnetic resonance imaging (MRI) scans of real birds. The CT and MRI scans were converted into 3D models of the skeleton and skin. VR applications were then created to simulate equipment interactions with the models. The initial CT scan data set included large and small birds representing different phenotypes.
Beyond the Laboratory: Broadening the Impact of University Research Through Effective Technology Transfer

Transitioning research from the laboratory to commercial reality has long been recognized as a major challenge in the technology development and transfer enterprise. So much so that the National Science Foundation (NSF) developed the Innovation Corps (I-Corps) education and training program for faculty, researchers, and students with the goal of broadening the impact of university research by focusing on technology transfer beyond the laboratory. The I-Corps program centers on the development of a Business Model Canvas as a strategic tool for developing a lean startup business model. It provides a visual representation for helping to identify the value proposition, customer base, financial model, and infrastructure needs of a new business or product venture.

Georgia Tech is one of nine national nodes that supports the I-Corps program. The Agricultural Technology Research Program (ATRP) recently participated in an abbreviated version of the training, which we dubbed I-Corps Lite. The I-Corps Lite training primarily focused on helping researchers identify the true value propositions for their technologies by better understanding the potential customers’ needs and market opportunities. Seven project teams completed the training, which was divided into two sessions.

In the first session, researchers formulated value proposition hypotheses that they believed made the business case for their technologies. The teams were then tasked with conducting 30-plus interviews with industry members to either validate or invalidate the value propositions. This proved to be quite a challenging task, as I-Corps instructors insisted that the project teams not talk about the actual technologies during the interview process. The purpose of this customer discovery exercise was to get honest and direct feedback without biasing the opinions of those being interviewed. The project teams accepted the challenge and conducted many of the interviews during the 2019 International Production & Processing Expo (IPPE) in Atlanta. The IPPE was the perfect environment to solicit feedback, as it is the largest annual tradeshow for the poultry, meat, and feed industries.

During the second session, researchers discussed how the interviews helped to either refine the value propositions or identify new perspectives on market potential. It was mentioned that the interviews also helped to determine the true customers and their perceptions of the technologies and solutions being developed.

This I-Corps Lite training experience was really eye-opening for many of our researchers and project teams. It was extremely helpful in driving new perspectives on what it takes to transition technologies from the laboratory into the commercial marketplace. Researchers were able to test their entrepreneurial prowess and hone their customer discovery and value proposition development skills in a real-world setting. None of this would have been possible without the incredible I-Corps training team of Melissa Heffner and Colin Ake of Georgia Tech’s VentureLab, which manages the I-Corps program at Tech. And, we owe a significant thank you to many of our industry partners who provided critical feedback to our project teams through the customer discovery phase of the program.

However, the training was just the beginning. Project teams are now able to implement these concepts on current and future projects as we seek to improve how we “transform poultry, agribusiness, and food manufacturing through advanced technologies.”

Doug Britton, Ph.D.
ATRP Program Manager

Seven ATRP Project Teams Completed an Abbreviated Version of the NSF I-Corps Training Program

- John Pierson, Aklilu Giorges – Novel Separations: a novel dynamic filtration system to separate fats, proteins, and solids from food processing wastewater in a way that the materials do not become entrained in the filter and reduce system efficiency.
- Jie Xu, Marc Zanghi – Phosphorus Recovery Using Magnetic Nanoparticles: using specially designed nanoparticles to capture phosphorus in various wastewater streams and recover them as a value-added byproduct.
- Wayne Daley, Brandon Carroll, Sim Harbert – Bird Audio Monitoring: monitoring the vocalizations of broilers in a growout environment to perform early detection of anomalies and improve overall animal management processes.
- Milad Navaei, Ardalan Lotfi – Multi-sensor System: novel sensor platform for detecting ammonia and other gasses in harsh environments without degradation of the signal or sensor itself.
- Comas Haynes, Stephanie Richter, Daniel Sabo – Ice Slurry Technologies: leveraging ice slurry in conjunction with mechanical systems as an alternative to water to improve the chilling of poultry carcasses.
- Ai-Ping Hu – Intelligent Cutting: capturing the external geometry of poultry carcasses, mapping it to internal physiology to generate unique cutting paths for each bird to perform robotic deboning.
- Colin Usher, Hal Jarrett – Growout Robotics: developing an autonomous robotic platform to perform tasks and capture meaningful data in a live animal environment.

References:
1. nsf.gov/news/special_reports/i-corps
2. nonlinearthinking.typepad.com/nonlinear_thinking/2008/07/the-business-model-canvas.html
Researchers Examine the Effects of Salinity in Slurry-Chilled Poultry

Over the past several years, researchers with the Georgia Tech Research Institute (GTRI) have been investigating ice slurry as an alternative medium for use in poultry chilling systems. Poultry processors typically use chilled water to cool the temperature of chicken carcasses and impede microbes that may pose a food safety risk. Researchers have found that ice slurry, a mixture of tiny ice crystals and liquid water, cools carcass core temperatures faster while helping to reduce harmful microbes at a greater rate.

While the slurry exhibits these two important advantages, a key component in its composition presents new challenges for the team. The culprit is salt.

Salt is a vital part of the slurry composition. It acts as a freezing point depressant as well as an anti-agglomerate, keeping the ice particles in a near-homogenous mixture. However, researchers soon realized that the levels of salt within the slurry could potentially cause carcass salt uptake issues and reduce antimicrobial effectiveness.

“We like to think of salt as a necessary challenge. It is essential in making the slurry, but at the same time, it’s a double-edged sword as it poses regulatory and food quality concerns,” says Dr. Comas Haynes, GTRI principal research engineer and project director.

The U.S. Department of Agriculture (USDA) regulates sodium levels in food products. As a result, researchers must determine the extent of carcass salt uptake. To accomplish this, they have to measure levels of salt within the meat product.

“We settled on a USDA-approved dry ashing method,” says Dr. Daniel Sabo, a GTRI research scientist and the project’s lead chemist. “The ash content is a measure of the total amount of minerals present within a sample, including sodium and chloride ions, which make up salt.”

Dry ashing involves heating samples (in this case, skin and meat samples from the carcasses) at high temperatures, generating ash. The ash is then analyzed using an ion chromatograph to determine the chloride concentration in parts per million per gram (ppm/g).

“Salt and sodium are not synonymous. Sodium is a component of salt,” explains Sabo. “We are focusing on the chloride portion, because sodium is found everywhere and is a common contaminant.”

To determine salt uptake, researchers conducted tests where carcasses were exposed to four different chilling treatments for 60 minutes. The treatments included air chilled, chilled water, 4.5% salinity chilled water, and 15% salinity chilled water. Post chill, three samples were collected from each carcass: white meat, dark meat, and skin (each of which were anticipated to have varying tendencies of salt uptake, with skin being the primary receptor). The samples were then dry ashed and analyzed using ion chromatography.

Initial results show that the skin contains the highest chloride concentration compared to the white and dark meat. However, there was a higher concentration of chloride in the white meat samples of carcasses exposed to 15% salinity compared to those exposed to 4.5% salinity. Carcasses chilled in 15% salinity showed 4, 6, and 100 times higher ppm/g chloride concentration in skin, dark meat, and white meat, respectively, compared to the carcasses chilled in 4.5% salinity.

According to Haynes, 4.5% salinity is a more likely scenario, while 15% salinity at 60-minutes exposure was used as an aggressively high setting to test extreme conditions. Therefore, the results may indicate a threshold salinity above which salt uptake increases in a disproportionate manner. In other words, there may be a breakthrough effect at some salinity between 4.5% and 15%.

The team will use these results to form an initial data set, which will be expanded as more tests are conducted. The goal is to populate a database that will be a resource in analyzing salt uptake tendencies against key regulatory and labeling limitations imposed by the USDA’s Food Safety and Inspection Service (FSIS).

The team also plans to investigate the salt’s effect on the commonly used antimicrobial peracetic acid (PAA). PAA naturally breaks down into acetic acid and hydrogen peroxide. Initial reports have shown that salt accelerates this deterioration. PAA degradation rates will be explored for a range of salinities.

“The ice slurry chilling media presents an interesting trade-off effect regarding PAA concentration,” says Haynes.

The immiscibility of PAA within solid ice, he explains, causes a given volume of PAA to have an initially higher concentration in the slurry liquid portion; however, the decomposition of PAA in salt counters this heightened concentration.

“Characterizing this trade-off effect across different initial settings such as slurry ice fraction, liquid phase salinity, and PAA concentration will be an important contribution to effective application,” adds Haynes.

While research is ongoing, Haynes says results to date continue to show that ice slurry indeed has potential for poultry chilling.
3D Modeling Technology for Live Production Through Processing

Colin Usher, senior research scientist in the Georgia Tech Research Institute’s (GTRI) Agricultural Technology Research Program, discusses his work on the development of a novel 3D scanning and reconstruction system. The system, consisting of multiple stereo cameras, generates high-fidelity models of live chicken and processed parts.

Q: PoultryTech – What industrial challenge is the project addressing?
A: Usher – This project addresses the need for enhanced data that could be used for better management and control of poultry operations from live animal husbandry through processing.

Q: PoultryTech – How is the proposed approach different from current practice?
A: Usher – Currently, equipment in processing plants is typically adjusted once based on an estimated average weight of each chicken determined by the weight of the hauling trucks as they enter the facilities and an assumption on the number of chickens on the truck. This technology could enable the design of flexible equipment that could adjust based on the shape and size of individual birds.

For live operations, product delivery schedules are based on an estimate of the average bird live weights and the end product for a customer. This technology could enable higher fidelity estimation of flock weight and sizes, in order to allow for better prediction and routing of the birds for processing.

Q: PoultryTech – How does the 3D scanning/reconstruction system work?
A: Usher – The system consists of three or more sensors (the current prototype uses four) positioned around the product. The system simultaneously captures the target and is able to reconstruct a full 360-degree model based on each of the individual side views from each sensor.

Q: PoultryTech – What industrial challenge is the project addressing?
A: Usher – The need for enhanced data that could be used for better management and control of poultry operations from live animal husbandry through processing.

Q: PoultryTech – What is the significance of capturing 3D scans and reconstructing a 360-degree model?
A: Usher – The ability to capture and generate accurate 360-degree

3D models of live, dead, and individual parts of chickens opens the possibility for designing processing systems that are able to operate on a “lot of one” (refers to a system’s ability to adapt in real-time to changes in product types during processing). Additional possibilities include enhanced sorting on-line in facilities based on target products and customers as well as improved ability to predict yields and plan live production schedules.

Q: PoultryTech – Why was the Intel RealSense camera chosen?
A: Usher – We are constantly evaluating the newest sensors as they come to market. For this project, we chose the Intel RealSense based on capabilities and cost. We have also used Microsoft Kinect and FLIR (formerly PtGrey) Bumblebee sensors. However, the algorithms being developed are designed to be sensor agnostic and portable to several different sensing systems.

Q: PoultryTech – What are the initial testing results?
A: Usher – We are currently evaluating the newest sensors as they come to market. For this project, we chose the Intel RealSense based on capabilities and cost. We have also used Microsoft Kinect and FLIR (formerly PtGrey) Bumblebee sensors. However, the algorithms being developed are designed to be sensor agnostic and portable to several different sensing systems.
system housed in the University of Georgia’s (UGA) College of Veterinary Medicine as ground truth. We capture a chicken using our system, then move the chicken into the CT scan system and capture the chicken in the same pose. We then reconstruct the models in a CAD (computer-aided design) system and compare the accuracies. Initial results are very promising, and we are now working to quantify the exact error.

Q: PoultryTech – What are the potential applications for the live side and the processing side and how would each benefit poultry processors?
A: Usher – On the live side, such a system might be helpful for predicting processing schedules for individual poultry houses based on customer needs. There is the potential to use the volumetric data for estimating the weight of the birds. In addition, this is a tool that could be very helpful for phenotyping and measuring performance of the parent flocks. On the processing side, the system could provide the ability to develop “smart” equipment that can adjust to each bird, thus increasing processing flexibility and improving yield.

In addition, other benefits could be the ability to perform product sorting for size and/or conformity as well as enhanced quality assessments. However, before any of these concepts can be tested, the technology for generating these models must be developed.

Q: PoultryTech – What is the project’s long-term goal and the potential impact on poultry processing advancements?
A: Usher – The long-term goal of this project is to develop a technology for rapid on-line generation of high-fidelity models of both live birds and birds during processing that can be used to enable future technological enhancements for processing as well as improve management through data.

Q: PoultryTech – What has been the most challenging and/or rewarding aspect of working on the project thus far?
A: Usher – Capturing and generating the models has been challenging. Current calibration methods do not yield high enough accuracy when attempting to build high-fidelity models, so trying new approaches for performing this calibration has been a primary goal. Currently, the approach we are using is promising, and seeing this system come together is the reward.

Q: PoultryTech – What are the project’s next steps?
A: Usher – We have developed a calibration approach that is promising. Next steps are to generate a new set of data using our system and the CT scan system at UGA and to quantify the accuracy of our system.

A: PoultryTech – Is there anything else you would like to add?
A: Usher – This technology is one that, if successful, has application through all facets of the integrated poultry processing chain. It has applicability in live production in commercial poultry houses; it has applicability in all aspects of processing from first through third processing; and it even has applicability related to packaging and product presentation as a QA (quality assurance) system.

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Technical Assistance Is Just a Phone Call Away

The Agricultural Technology Research Program (ATRP) provides no-cost technical assistance to Georgia-based firms and individuals in the poultry industry. These assists range from simple inquiries regarding information or help needed to address a problem to extensive on-site consultations in which researchers collect data and provide a report on their findings and recommendations. The program also offers in-plant energy usage/cost assessments and workplace safety evaluations.

ATRP uses input from all assists to gauge situations calling for new research initiatives in energy, environmental, safety, and other areas. Researchers provided more than 25 technical assistance services in 2018.

To inquire about the program or to schedule an assist, call ATRP Program Manager Doug Britton at (404) 407-8829 or email him at doug.britton@gtri.gatech.edu.

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Did You Know?

The Occupational Safety and Health Administration (OSHA) produces a twice monthly online newsletter that provides information about workplace safety and health.

QuickTakes shares the latest news about enforcement actions, rulemaking, outreach activities, compliance assistance, and training and educational resources.

Subscriptions are free.

Subscribe at: osha.gov/quicktakes
**RESEARCHER PROFILE**

**Judy Song**

*Job title:* Senior Research Engineer  

*Education:* Ph.D. in Chemical Engineering

*Areas of research expertise:* Novel sensor development for environmental monitoring; bacteria detection; gas chromatography-mass spectrometry instrumentation and method development for volatile organic compound detection and quantification

*List of any poultry industry projects you're working on and your role:* Dynamic laser speckle imaging for detecting living bacteria (Project Director)

*What I find most rewarding about working on poultry industry projects:* The “Chicken” actually tells you everything: Biology, Chemistry, Imaging, Robotic Automation, and more

*A talent I wish I had:* Play multiple musical instruments

*Another occupation I'd like to try:* Gardener

*My first job:* Research Assistant in the Department of Civil and Environmental Engineering at the University of South Florida in Tampa

*If I could meet someone famous, who would it be and why:* Madame Marie Curie because her amazing work saved so many people's lives, and I became a scientist under her inspiration

*One thing people may not know about me:* I love cooking and I may not be that bad at it

*My day would not be complete without:* Prayer

*The last book I read:* Staring at the Sun by Irvin D. Yalom

*The last movie I saw:* Avengers: Endgame

*My favorite song:* “You Raise Me Up”

*My motto:* Do what is right, not what is easy

*My hobbies:* Running, tennis, gardening

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**MARK YOUR CALENDAR**

**UPCOMING EVENT**

August 12-14, 2019  
Hilton Sandestin Beach Golf Resort & Spa  
Destin, Florida

The 2019 National Safety Conference for the Poultry Industry is designed specifically for poultry facility and corporate safety personnel. The three-day event features key presentations on important industry topics and updates on government policy. Other highlights include breakout sessions for discussing best practices and current challenges, as well as networking and knowledge exchange opportunities with other safety and health professionals.

Register to attend at: uspoultry.org/educationprograms
The U.S. Poultry & Egg Association (USPOULTRY), National Chicken Council, National Turkey Federation, and United Egg Producers have released an updated economic impact study that highlights the positive impact the poultry industry has on jobs, wages, and federal and state revenue in the United States.

A dynamic and integral part of the national economy, the U.S. poultry industry provides 1,984,784 jobs, $108.9 billion in wages, $495.1 billion in economic activity, and $38.5 billion in government revenue. According to USPOULTRY, since the last study conducted in 2016, the poultry industry has created 302,515 additional jobs, and the economic impact has increased by 11 percent.

“We are pleased to continue providing this valuable tool across the industry that shows the positive economic impact the poultry industry has on our nation and communities,” said John Starkey, president of USPOULTRY.

The data is hosted on interactive websites that can be viewed collectively or by individual product, and then sorted nationally by state, congressional district, state house district or state senate district, and county. For more information about the U.S. poultry industry’s economic impact, visit:

- poultryfeedsamerica.org
- chickenfeedsamerica.org
- turkeyfeedsamerica.org
- eggsfeedamerica.org

USPOULTRY funded the economic impact study, which was conducted by New York City-based John Dunham & Associates. The study was updated using the most current methodology available and uses data from 2018.

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**ATRP Advisory Committee Reviews Research Progress**

On April 23, the Agricultural Technology Research Program (ATRP) held its annual Advisory Committee Meeting. Project directors provided committee members with an update on program research projects as well as technology transfer and outreach activities. A round-table session was also held where committee members provided feedback and discussed future research opportunities, challenges, and directions with researchers.

The annual meeting serves as a key step in ATRP’s efforts to identify and conduct research projects that best address priority industry needs. ATRP extends its appreciation to the Georgia Poultry Federation and the individual committee members who give of their time and experience to help review and focus ATRP’s research program.
The overall VR system includes a headset and handheld controllers connected to a powerful graphics computer that generates 3D visualizations in real-time and presents realistic 360-degree views to the user.

In practice, a user selects a 3D sample bird from the database of scanned birds. The VR application next simulates the chosen equipment interface (cutting, handling, etc.) with the bird and displays the corresponding interactions. Any collisions with the bird skeleton are displayed as the user views the machine-bird interaction. This allows the team to test various manipulation algorithms on many bird phenotypes in a non-destructive way. Harbert says the team uses that data to assess the performance of the algorithms.

“The VR system has helped us explore extensive refinements of the manipulation algorithms that would have been difficult and time-consuming to do with real birds. This significantly improved testing efficiency,” adds Harbert.

Real Bird Testing

Having demonstrated success with the cutting algorithms in the VR environment, researchers are now extending the development pipeline to include tests with real birds. To do this, they mapped the cutting paths from the VR environment into required movements for a robot arm and outfitted a robot with a knife blade as its end effector or end-of-arm tooling. Testing is underway to address real-world implications such as accuracy, repeatability, and cutting and manipulation approaches.

Next Steps

Harbert says the team also plans to generate more 3D scans to obtain data of birds in different positions and orientations. Such data will help to improve and refine the VR-based testing model by expanding the range of birds that can be accommodated by the system.

Birds have various shapes and sizes, so a challenge for any automated processing system is to adjust the operating parameters to accommodate each bird. This adjustability is key to maximizing yield and improving throughput, which directly impact a poultry processor’s bottom line. Researchers believe their VR-based phenotyping work will help in this regard.

“We think the VR system has the potential to help poultry equipment manufacturers quickly create robotic automation solutions that respond to product variability and customer requirements,” says Harbert. “These approaches may also pave the way to implement co-robotic solutions that assist workers in performing these somewhat dangerous and repetitive tasks.”

The team acknowledges the following industry and academic partners for their collaboration on this research project: Mar-Jac Poultry, University of Georgia Department of Poultry Science and College of Veterinary Medicine, Auburn University Department of Poultry Science, USDA-ARS Richard B. Russell Research Center, and the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University.

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