Researchers Exploring Co-Robotics for Automatically Loading Poultry Deboning Cone Lines

Researchers with the Georgia Tech Research Institute’s (GTRI) Agricultural Technology Research Program are exploring the use of collaborative robots for materials handling tasks in poultry processing plants. Also known as cobots, these robots are designed to work safely alongside humans in any number of tasks. The GTRI team has constructed a robotic test bed centered on the Baxter robot by Rethink Robotics. Baxter is learning to pick and place chicken front halves (carcasses without legs and thighs) on cones for deboning during further processing. The project is one of many underway aimed at demonstrating the next generation of poultry processing.

“Even with today’s automated deboning machines, the loading of the machines with front halves is the one part of the operation that is still manual,” says Sean Thomas, GTRI senior research technologist and project director.

In fact, the operation is a part of the very labor-intensive deboning task in further processing where loads of carcasses need to be lifted from a hopper and placed onto moving lines of cones for subsequent deboning. Such operations are part of an unstructured environment and require flexibility to accommodate the natural variability associated with birds of different sizes and weights. As a result, programmable automation in this part of poultry processing facilities in the past has proven difficult and costly to implement. However, recent developments in low-cost robotics and advances in imaging sensors offer new possibilities for automation.

The Baxter robotic platform is relatively low priced for a two-armed robot, and comes with software that allows for complex dynamic interactions. This makes it an excellent test bed for the research team as it can handle many repetitive production tasks that are typically challenging to automate.

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Wow! It is amazing how fast 2017 has gone by. This year has been another year of progress for the Agricultural Technology Research Program (ATRP). I am so proud of our researchers and staff who work diligently every day to fulfill our vision of driving transformational innovation. This issue of PoultryTech highlights research initiatives that are focused on reimagining poultry production and processing with an eye on creating the “Poultry Plant of the Future.” From on-farm production systems to dynamic 3D modeling and co-robotics, we are “thinking outside the box” from the growout house to the processing line.

Continuing with that theme, we are excited to once again announce our plans to participate in the upcoming International Production & Processing Expo (IPPE) to be held January 30-February 1, 2018, in Atlanta. We will join thousands of other exhibitors at the trade show of the year for the poultry, meat, and feed industries. If you are in attendance, stop by our Booth B5133 to see and learn more about our latest projects.

We are also pleased to co-host with BMC UK, the 2018 International Food Automation Networking Conference (IFAN) scheduled for April 19-20, 2018, here at Georgia Tech. The conference will focus on robotics and automation, emerging/future technologies, IT cyber systems, and environmental sustainability for the food industry. The 2016 conference drew food and allied industry professionals from seven European countries, the United States, Canada, and Australia. We are hoping to draw the same level of interest again with the goal of becoming the premier Food Automation conference.

For more information on both the IPPE and IFAN, see the entries on page 8.

Lastly, on behalf of ATRP, I would like to wish you a Happy Holiday Season! And, as always, we welcome your comments, suggestions, and ideas on how we can work together to continue to advance our dynamic industry. Feel free to email me at doug.britton@gtri.gatech.edu.

Doug Britton, Ph.D.
ATRP Program Manager

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“We knew we could train Baxter to conduct many of the operations in the further processing areas of a poultry plant,” says Thomas. “Baxter has two, six degrees of freedom arms, which makes it more adaptable to perform the required tasks on the deboning cone line.”

Simply put, Baxter can be taught to pick and place the chicken front halves.

And, unlike most robots, Baxter has a comprehensive safety system that makes it feasible for working without traditional robotics safety barriers, allowing close proximity with workers in a processing plant.

“It is not as accurate or fast as some other robots, but the built-in co-robotic aspects make it a safe robot to work with while doing this research,” says Sim Harbert, GTRI senior research engineer, who is leading the project’s software architecture activities. “The Baxter platform also integrates with the Robotic Operating System (ROS) [a set of software libraries and tools that help researchers build robot applications], which allows for adding on sensors and control modules relatively easily.”

Specifically, each of Baxter’s arms is outfitted with a custom end-effector or hand that was designed and fabricated in-house. The end-effector uses suction to grasp the carcass on meat surfaces larger than about one inch in diameter. Several Microsoft Kinect 3D sensors are also integrated into the platform. These sensors are setup to detect grasping locations for the end-effector as well as the carcass cavity orientation for placing on the cone.

To test Baxter’s performance, the team constructed an experimental work cell. The work cell contains a bin in front of the Baxter robot where front halves are dropped from a chute. The Kinect 3D sensor is used to find the best grasping location for the carcass in the bin. The arm that has the best approach for the grasp location is moved into place to grasp and pick up the carcass. If it does not succeed in the grasp operation, Baxter notifies the human operator to assist. Otherwise, the arm picks up the bird and moves it to a position in full view by the Kinect sensor so that the orientation of its cavity can be determined. Once that is done, the carcass is placed on a cone next to the Baxter robot, and the arm waits for another carcass to be detected. The other arm can start grasping a carcass once the previous arm is out of the bin area.

Initial results showed a near 90 percent success rate of grasping and placing the front halves on a stationary cone.

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What if you could have accurate volumetric models of thousands of individual birds in your flock each and every day throughout their growth? Could you better predict yield, or measure their weight given their volume? Could you measure the distribution of crop fill and identify domination issues? These are some of the questions researchers at the Georgia Tech Research Institute (GTRI) are asking themselves. However, before these ideas can be tested, a tool must be developed to allow for generating such models, and that is no easy task.

Recent advances in sensor technology and new cutting edge algorithms enable the generation of highly accurate 3D model representations of objects. Examples of such technology include the Microsoft Kinect sensor and its Kinect Fusion algorithm. This algorithm allows for real-time capture and generation of a 3D model of objects. These models can be very high fidelity, as illustrated in Figure 1. However, one key requirement is that the objects being modeled are static. This is easy to achieve with people as you can ask them to hold still. Chicken, however, are another story.

In order to generate a 3D model, several processes are occurring simultaneously. While the target holds still, the sensor is moved around by hand or by robot. Then, 30 times a second, a 3D image is captured using the sensor. This image is represented as a surface, like the one shown on the left-hand side of Figure 1. When a new image is captured, the new surface has moved very slightly with the movement of the camera. The algorithms calculate how much and where the new surface has moved with respect to the previous one. Using this information, the new surface is integrated into a model containing all of the previous surfaces. A final step renders all of the surfaces and outputs a very detailed 3D model.

The key to this algorithm is that the data is coming in very fast so that the change between each subsequent surface is very small and there is a lot of overlap in the data. This allows the algorithm to accurately determine where the camera has moved, so it can add the new surface in the correct place in the model. In order for all of this to work, the target must remain still, otherwise there is movement in both the camera and the target that causes the whole algorithm to fail. Unfortunately, chicken move a lot, especially when you are pointing a camera at them!

In order to generate accurate models of chicken, an algorithm must be developed to allow for generation of a 3D model from dynamic, moving objects. Such an algorithm must allow both the camera and the target to move within reason. Fortunately, chicken are relatively simple objects, with a fairly static midsection and most movement coming from the head, tail, and legs. Figure 2 illustrates two surfaces from a sequence matched using the non-dynamic algorithms as described above. You can clearly see misalignment in the head and tail, while the bulk of the body was accurately aligned. These are the shortcomings that require the development of a new method.

The research team has been working with faculty and students in Georgia Tech’s School of Electrical and Computer Engineering to develop such an algorithm. The goal is to be able to generate a full 360-degree model of a chicken as it moves in front of a static sensor. To be able to do this, the team is implementing an advanced concept known as warp-fields. A warp-field is a discrete representation of a deformation of part of a larger model over time. This will allow the algorithm to create a static model that makes sense, even if the object it is modeling is moving and deforming.

If successful, researchers will have a new tool that allows for rapid generation of accurate 3D models of live chicken, right in their natural environment. This would open up the opportunity to explore several new frontiers, of which only a few were listed at the start of this article. Imagine the ability to have a robot driving through your flocks, generating 3D models of chicken on-the-fly, and providing accurate, actionable data in real time. Is any of this data of value to the farmers? I hope we get the opportunity to find out.

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New Techniques Allow for In Situ 3D Modeling of Live Chicken

BY COLIN USHER

Colin Usher is a research scientist in the Georgia Tech Research Institute’s Food Processing Technology Division.

Figure 1.

Figure 2.
On-Farm Production System

Alexander Samoylov, senior research engineer, discusses his exploratory research project that is evaluating the suitability and economic feasibility of using new technologies for on-farm bird harvesting and related tasks.

Q: PoultryTech – What is the objective of the research project?

A: Samoylov – With the on-farm production project, we are trying to present our vision of how the poultry process might look in the future. This project supports ATRP’s “Poultry Plant of the Future” initiative and tries to reimagine how poultry production operates.

The humane treatment and the reduction of stress experienced by the birds during production and processing is a priority for the poultry industry. One of the most stressful situations for broilers is the transport between the farm and processing facility.

The design of this new conceptual process eliminates live transport, and thereby reduces or eliminates the associated stressors. Another objective is to reduce the amount of manual live bird handling currently occurring. Handling live birds at the processing plant can be a rather unpleasant job that tends to have higher employee turnover rates. In addition to reducing the amount of manual live bird handling at the plant, the proposed process could also reduce the transportation expenses associated with moving the birds from the farm to the plant.

Q: PoultryTech – How does the on-farm system work?

A: Samoylov – The on-farm production system totally changes the current poultry live haul and live hang processes. The concept consists of two systems: a production trailer and a transport trailer. The production trailer is equipped with systems to receive birds from the poultry house, stun, shackle, and kill them. The transport trailer consists of guiding rails, electrical motors, and shackles arranged in a way that we can transport close to 4,300 birds in one trailer.

In the proposed production process, broilers are killed at the farm using the production trailer, and then transported to the processing plant in shackles using the transport trailer.

To make this process work, we created a mechanical systems design that will stun, shackle, and kill the birds on a mobile platform that can be easily moved around at the farm and to different farms. The system is designed to process up to 4,000 birds per hour, which is comparable to current industry live bird loading rates. The current design contains a stand-alone power system and was developed with farm operation in mind.

Q: PoultryTech – What are the results to date and the next steps?

A: Samoylov – The process flow and mechanical designs are 90 percent complete. We have filed a provisional patent, and are currently in the process of prototyping parts of the new system. Our ongoing work will continue to focus on improvements to the system and seamless integration through the entire process.

Q: PoultryTech – What are the advantages and disadvantages (if any) of the proposed approach?

A: Samoylov – There are several advantages of the proposed system:

- Improved bird welfare by removing live haul operations
- Elimination of DOAs (dead on arrival)
- Elimination of the live hang tasks at the processing plant
- Potential reduction in overall bird transportation costs

There are a few disadvantages of the proposed system:

- Higher initial capital investment
- Overcoming regulatory hurdles
- It is an unproven process
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Thomas says the next steps are to improve the accuracy and speed up the detection of the grasping location and cavity orientation. There are also plans to optimize the planning and execution of the robot’s motion.

As a complementary research objective, the team recently began testing a virtual reality (VR) system as a way of interacting with the robot from a remote location away from the processing line or even another building.

“The VR system allows a human operator to control the robot’s arms to direct it for better grasping. This human interactivity will be used to improve the robot’s performance over time,” says Harbert.

According to Thomas, the ultimate goal is to have a convincing demonstration of how robots can assist in further processing alongside human workers. While the Baxter robot is not wash-down ready, and thus would not be the appropriate robot to work in a processing plant, the technologies and software in this demonstration would be transferable to robots that can be used in processing environments.

The team believes the incorporation of robots for repetitive tasks such as cone loading would be a great step in moving toward intelligent automation in further processing as well as freeing plant workers to perform more value-added jobs.

“Approaching this from the co-robot perspective would allow for the integration of robots into further processing without requiring full automation, and would allow for humans to assist when something extraordinary happens,” adds Harbert.

Did You Know?

The National Chicken Council (NCC), the oldest and largest national association representing the U.S. broiler chicken industry (chickens raised for meat), has established industrywide standards for broiler chicken welfare. Called “Chicken Guarantees,” the standards are part of NCC’s Chicken Check In program, which serves as a resource for consumers to get the information they are seeking about how meat chickens are raised. NCC ensures that no matter which welfare standards a chicken company adheres to, or whether the birds were raised conventionally, organic, without antibiotics or free range, the following four principles hold true:

1. **Raised Cage-Free:** The majority of broiler chickens in the United States are raised in large, climate-controlled and ventilated barns, where they are free to move about, interact with other chickens, and have 24-hour access to fresh food and water.
2. **Free of Added Hormones and Steroids:** The U.S. government has banned the use of hormones and steroids in poultry since the 1950s.
3. **Monitored by Licensed Veterinarians:** Licensed veterinarians, who have a professional obligation to protect the chickens’ health and welfare, provide comprehensive health care programs for every commercial broiler chicken flock.
4. **Raised by Farmers Trained in Animal Welfare:** Farm owners are trained in handling and caring for chickens in order to provide a safe, healthy, and low-stress environment. If farmers or their employees mistreat chickens, they are subject to immediate disciplinary action, including termination and prosecution.

For more information, visit chickencheck.in/chicken-guarantees.
Safety Implications of Robotics in Food Production

BY AI-PING HU, PH.D.

The words “robot safety” immediately evoke images of The Terminator wreaking havoc on humans. The reality, it turns out, is much less sensational, especially in the context of manufacturing and production environments.

Go to the Occupational Safety and Health Administration’s webpage (osha.gov) and type in “robot” in the Accident Search field. What you’ll find are 39 reported incidents from 1984-2017. Of those, 28 resulted in a fatality. By comparison, 4,836 workers were killed on the job in 2015, the last year for which figures are available. The relatively tiny number of safety incidents associated with robots is a testament to effective safety guarding and in-plant processes.

The most common keywords associated with the reported robot incidents are: struck, crushed, and pinned. A new breed of collaborative robots (known as “cobots”) are just recently making their way onto manufacturing and production floors.

Cobots are equipped with compliant joints (for example, Rethink Robotics’ Baxter robot), force sensors at each joint (Universal Robots’ UR series of robots, KUKA’s LBR iiwa, and ABB’s YuMi), or constructed using soft materials with pinch points eliminated (ABB’s YuMi).

These innovations employ both passive and active means to help prevent accidental striking, crushing, and pinning. Similar to a car’s airbag system, the force sensors can detect abrupt changes in acceleration due to an unexpected collision. The cobot is then alerted to slam on its brakes within a fraction of a split-second.

Cobots have met the ISO 10218-1 (also: ANSI/RIA R15.06) Standard for when guarding is not required and there has been an increasing number of them out in the wild working right alongside people.

So far, the above has only considered robot safety from the point of view of “How can we protect workers from robots?” (an inherently reactive stance). I submit that an equally valid and perhaps more enlightening question is the more proactive “How can robots help prevent injuries in the first place?”

For instance, of great importance to our industry is the prevention of repetitive stress disorders arising from poultry processing tasks. With the capability to work right alongside people, cobots have the potential to permit new ways of preventing worker injuries by improving ergonomics.

A task’s ergonomics can be improved in two ways. First, you can re-design the task (not always possible). Second, you can find an alternative way to perform the stressful parts of the task. Today, you will find examples of automobile manufacturers using cobots to help assemble the cramped interior of cars while allowing people to remain standing upright. Also, still in the research stage, you will find examples like the Aucto robot at MIT that resembles a backpack with arms. Aucto can be worn by and assist a worker in lifting, reaching, and supporting activities. And, of course, sometimes tasks arise that require a fundamental dexterity that is irreducible to multiple sub-tasks (such as bird shoulder deboning), in which case the only completely safe and economical option is to fully and intelligently automate it.

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Technical Assistance Is Just a Phone Call Away

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. In-plant energy usage/cost assessments and workplace safety evaluations are also offered.

ATRP uses input from all assists to gauge situations calling for new research initiatives in energy, environmental, safety, and other areas.

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.
Georgia Manufacturing Extension Partnership Launches Outreach Initiative for Food Processing Manufacturers

Georgia is one of the nation’s leading agriculture states, with the industry contributing about $74.9 billion to the state economy each year.

A related sector — food processing — is a strong and growing component of the Georgia economy, and accounts for $11 billion to $12 billion each year of the state’s gross domestic product. Food processing also employs 69,000 across the state, with 10,000 of those jobs being created since 2010, according to Georgia Power’s 2016 Food Processing Industry Report.

It’s that strength in food processing, which comprises the largest segment of Georgia’s manufacturing sector, that led to the Georgia Manufacturing Extension Partnership’s (GaMEP) new initiative focused on those manufacturers’ unique needs.

GaMEP, a federally funded economic development program at the Georgia Institute of Technology’s Enterprise Innovation Institute, works with manufacturers across Georgia to help them remain viable and economically competitive.

“Food processing comprises many different products and sizes of manufacturers and it is important to assure their viability and growth,” said GaMEP Director Karen Fite. “This effort is in recognition of where the growth is occurring in the manufacturing sector and we want to make sure we’re applying our resources and expertise, as well as cutting edge research coming out of Georgia Tech, that can help our manufacturers.”

Damon C. Nix, GaMEP’s senior project manager, is leading the food manufacturing programming, which includes coaching, analysis, and consulting in:

**FOOD SAFETY**
- Compliance with the Food and Drug Administration’s (FDA) new Food Safety Modernization Act (FSMA) requirements.
- Management system implementation and audit team support.

**ENERGY MANAGEMENT**
- Energy assessments to identify cost reduction and performance improvement opportunities.
- Companies with fewer than 500 employees at a plant site may qualify for a free energy assessment through Georgia Tech’s Industrial Assessment Center program.

**ENVIRONMENTAL SERVICES**
- Environmental compliance services and management system (ISO 14001) support.
- Environmental Protection Agency P2 grant-funded projects that support pollution prevention through reduced greenhouse gas emissions, water usage, and hazardous materials generation.

**WORKER SAFETY AND HEALTH**
- Implement lean/process improvement approaches to safety problem solving.
- Partner with the Georgia Tech Research Institute’s Food Processing Technology Division to support Occupational Safety and Health Administration rules compliance, applied research, and technology solutions.

**WORKFORCE DEVELOPMENT**
- Operational Leader and Frontline Supervisor Training.

“Georgia’s food processing GDP ranks it sixth in the country and we rank sixth in employment,” Nix said, noting the state has roughly 680 food processing manufacturers, including the 127 that either relocated to Georgia or built new facilities here since 2010.

“The GaMEP has created significant results serving manufacturers overall,” Nix said. “We want to continue that momentum in food processing. Georgia’s manufacturing industry remains competitive and continues to grow because the food processing industry is expanding. We want food processors to know that the GaMEP is a resource to support their continued growth.”

Source: Georgia Manufacturing Extension Partnership (GaMEP) – gamep.org

For more information about GaMEP’s Outreach Initiative for Food Processing Manufacturers, email Damon Nix at damon.nix@innovate.gatech.edu.

Georgia is one of the nation’s leading agriculture states, with the industry contributing about $74.9 billion to the state economy each year.
Visit ATRP’s Exhibit in Booth 5133 – Hall B at the 2018 International Production & Processing Expo

The Agricultural Technology Research Program (ATRP) is excited about its plans to participate in the 2018 International Production & Processing Expo (IPPE), scheduled for January 30-February 1, 2018, at the Georgia World Congress Center in Atlanta.

ATRP’s exhibit will highlight the program’s research advancements and display prototype systems that seek engineering solutions that enhance process efficiency and product safety in today’s poultry plant. Program researchers will be available to answer questions, and a program video and handouts will describe current projects.

THE EXHIBIT WILL BE LOCATED IN EXHIBIT HALL B, BOOTH 5133.

The IPPE is a collaboration of three trade shows — International Feed Expo, International Meat Expo, and the International Poultry Expo — representing the entire chain of protein production and processing. The event is sponsored by the American Feed Industry Association, North American Meat Institute, and U.S. Poultry & Egg Association.

For more information, visit ippexpo.org.

Register Early for the International Food Automation Networking Conference (IFAN)

The 2018 International Food Automation Networking Conference (IFAN) is scheduled for April 19-20, 2018, at the Georgia Tech Hotel and Conference Center in Atlanta. IFAN 2018 will focus on robotics and automation, emerging/future technologies, IT cyber systems, and environmental sustainability for the food industry. Register at ifan.gtri.gatech.edu today to network and hear experts discuss R&D challenges/opportunities for creating the food production system of the future.

Founding sponsors