The Agricultural Technology Research Program’s (ATRP) vision to “Transform Poultry, Agribusiness, and Food Manufacturing Through Advanced Technologies” affords us broad opportunities to review and explore a wide variety of technology domains. In FY 2019, ATRP supported 10 exploratory research efforts that focused on driving proof-of-concept and higher risk discovery in narrowly defined areas that should they yield results could open up new opportunities for broader technology applications. These included projects ranging from the development of 3D image-based automated perception to support robotic bin picking to using laser pattern recognition to detect bacteria. An additional 11 larger research endeavors with more near-term expected outcomes were also supported by the program. These included topics such as the use of magnetic nanoparticles for the capture of phosphorus from wastewater and the extraction of free fatty acids from rendered oils and the development of autonomous ground robotics for use in growout/breeder house and live animal environments. Many of these research efforts are conducted in active collaboration with our industry partners, and we are very thankful for their generous support.

While research is a mainstay of ATRP, our Outreach, Education, and Technology Transfer activities are equally as important in achieving our vision. In addition to publishing our biannual PoultryTech newsletter, ATRP hosted several school groups and industry tours at our facility throughout the year. Participation in the National Safety Conference for the Poultry Industry continued to grow in FY 2019 through the collaborative partnership with the U.S. Poultry & Egg Association (USPOULTRY). ATRP also participated in the International Production & Processing Expo (IPPE) and other industry events as a means of connecting with our industry stakeholders and partners. On the technology transfer front, seven teams of researchers participated in an abbreviated version of the National Science Foundation (NSF) I-Corps training, which is designed to accelerate the transition of technologies from the lab into the commercial setting. This led to numerous discussions with industry and allied partners about the value proposition of technologies currently under development.

So, 2019 was indeed a very busy and productive year for ATRP. We are pleased to share with you what we have accomplished this past year, but are just as anxious to dive into the work ahead. As always, we sincerely appreciate the support and involvement of all of our partners and stakeholders, and invite all of you to join us as we seek to “Create the Next” in poultry, agribusiness, and food manufacturing.

Doug Britton, Ph.D.
ATRP Program Manager
FY 2019 PROGRAM HIGHLIGHTS
July 1, 2018–June 30, 2019

Total Funding: $2,072,460
Annual funding provided by the State of Georgia

23% Environmental and Biological Systems Research
21% Automation and Robotics Research
20% Technology Transfer/Outreach/Technical Assistance
18% Imaging and Sensing Research
11% Food Safety Research
9% Program Support

By the Numbers

2 Patent applications
8 Research prototypes in various stages of development
4 Invention disclosures
10 Exploratory research projects
45 Published articles, papers, and presentations
14 Participating industry and academic partners
26 Technical assistance service requests fulfilled

Outreach Activities

SPECIAL THANKS
Industrial collaborators support research projects by providing industry expertise and access to facilities for data collection and systems testing and contributing in-kind and cash support on an “as needed” basis. Academic partners collaborate with research teams by providing cross-disciplinary expertise and experience as well as access to university research facilities.

Auburn University
Department of Poultry Science
Case Farms
Darling Ingredients
Fieldale Farms
Gainco
Georgia Institute of Technology
College of Computing
George W. Woodruff School of Mechanical Engineering
School of Biological Sciences
School of Chemical and Biomolecular Engineering
School of Earth and Atmospheric Sciences
School of Electrical and Computer Engineering
Wallace H. Coulter Department of Biomedical Engineering (in partnership with Emory University School of Medicine)
Gwinnett County Department of Water Resources
Harrison Poultry
KWJ Engineering
Mar-Jac Poultry
TechnoCatch
University of Georgia
College of Veterinary Medicine
Department of Poultry Science
USDA-ARS Richard B. Russell Research Center
Wayne Farms
Virtual Reality-Based Optimization of Systems
Researchers continued to evaluate the feasibility of using virtual reality (VR) technologies to create frameworks for testing, evaluating, and optimizing various systems in a poultry processing environment. During FY 2019, researchers tested cutting trajectories on VR models, specifically evaluating techniques for responding to variations due to genetic phenotypes. The expression of an individual bird’s genotype and interaction with the environment is its phenotype. Using VR technology for initial testing and evaluation of automated solutions eliminates the need to use real product or build and test actual hardware.

Phosphorus Removal/Recovery Using Magnetic Nanoparticles
Researchers continued to optimize a magnetic nanoparticle (MNP)-based treatment method to remove and recover phosphorous from poultry processing wastewater. During FY 2019, a new regeneration chemistry was developed, which allowed the MNPs to be used more than 20 times to treat effluent obtained from a local poultry processing facility. Concentrations of phosphorus and MNPs were measured in each step to track the input and output of the chemicals. There was no observed reduction on phosphorus removal efficacy even after 20 cycles of MNP regeneration. It is estimated that the overall cost for chemicals needed to treat 1,000 gallons of wastewater containing 20 ppm of phosphorus would be about $0.72, which is about half of the cost associated with the current industry practice.

Removal of Free Fatty Acids from Rendered Oil
Researchers continued to investigate the removal of free fatty acids (FFAs) from various oil systems using functionalized magnetic nanoparticles (MNPs). In FY 2019, they developed a new method for the synthesis of MNPs and were able to remove FFAs from volumes of oil up to 1 liter without any loss of adsorption capacity. The new synthesis method also showed a reduction in time and chemical requirements for regeneration compared to the original method, specifically 75% less time and 80% less chemicals. Researchers believe the functionalized MNPs are very competitive and continue to demonstrate a significantly higher adsorption capacity compared to the best available adsorbents currently used in industry.

Salt Management Techniques for Viable Ice-Water Slurry Within Poultry Processing
Researchers continued to investigate the feasibility of using ice-water slurry (where salt is used as a freezing point depressant) as an alternative chilling medium. FY 2019 work investigated the extent of carcass salt uptake using a dry ashing method. The ash content is a measure of the total amount of minerals present within a sample, including sodium and chloride ions, which primarily make up the salt. Carcasses were chilled at different salinity concentrations of chilled water, and samples were taken. Initial results show that the skin contains the highest chloride concentration in comparison to white and dark meat. The goal was to initiate data that can be used as a resource for analyzing salt uptake tendencies against labeling limitations imposed by food product regulations.
Multi-Function Sensory System for Smart Poultry Farming
Researchers continued the optimization of a multi-function micro-sensor system that is initially targeted to measuring levels of ammonia in a farm environment with minimal interference from other sources. During FY 2019, they investigated a new scaled-down sensor design. The design includes an improved thermal conductivity detector that provides greater tolerance to heat stresses. Researchers also developed a new thermal balanced measurement technique that significantly enhances the signal-to-noise ratio of the sensor. The scaled-down design also reduces power consumption while providing excellent shelf life and reliability under exposure to corrosive gases.

Poultry System Simulation Model
The Poultry System Simulation Model (nicknamed PRYSSM by researchers) can be used to simulate a typical poultry processing plant’s water, energy, and labor usage. During FY 2019, researchers evaluated two ATRP technologies under development: Novel Separation Technologies for Poultry Processing Liquid Streams and Phosphorus Removal/Recovery Using Magnetic Nanoparticles. PRYSSM was used to simulate the effects of each technology during various stages of poultry processing, resulting in detailed case studies. Results proved PRYSSM’s effectiveness as a tool that plant management can use to identify areas for usage reductions and process improvements, including the implementation of new technologies.

Growout House Robotics Advanced Automation and Demonstrations
Researchers continued to optimize and evaluate a ground robot’s ability to perform broiler and broiler-breeder rearing and management tasks in poultry growout houses. During FY 2019, the robot hardware was significantly upgraded using a newer, more accurate arm with a suction end effector for egg picking, a new 3D stereo imaging sensor, and a more powerful control PC. Software algorithms for detecting chickens and eggs using machine learning were developed and tested in test houses with live chickens. In addition, a first-generation prototype arm designed for removing mortality was fabricated and tested. The research culminated in a several months-long field trial of the robot navigating a small test facility and picking eggs fully autonomously.

Audio Processing for Animal Wellness and Well-Being Assessment
Researchers further enhanced the data acquisition and analysis capability of the Growout Monitoring System. During FY 2019, the team designed a hardened system for audio acquisition in a broiler growout house. Researchers also implemented a first-generation software interface to demonstrate the utility of previously developed algorithms for audio processing. The ability to process video was also demonstrated. They believe the project is a first step in creating the next generation of systems to support the management of animals reared in confined environments. Such systems could allow end users to describe and control conditions using not only temperature and humidity but also quantitative descriptors for well-being.
Automated Cone Loading with Low-Cost Manipulation
Researchers began development of a novel system to automatically load front halves on cones with and without a robot for deboning operations. FY 2019 efforts focused primarily on designing a system for singulating, orienting, and transferring a carcass from a conveyor onto a cone. Specifically, researchers improved the design of the system’s conveyor and developed a new orientation device. Carcasses can be loaded onto the cone facing forward or backward while still parallel to the conveyor. This reduced the bird cavity position to only two possible orientations. Further work is underway with a focus on improving reliability and speed.

Novel Separation Technologies for Poultry Processing Liquid Streams
Researchers demonstrated the scalability of the separation surface and holder (i.e., filter and filter chamber) of the Dynamic Filtration System by using commercially available mesh strainer baskets and associated sanitary housing. This work further validated the system as a working prototype for steady-state in-plant filtering at 100 microns. Researchers believe the system shows promise as a new tool for process water treatment with the recovery of food grade fine suspended solids (fats and proteins) essential for improving supplier sustainability index performance.

Intelligent Cutting 2.0
Researchers updated key components of the Intelligent Cutting System to meet processing plant speed requirements for chicken deboning on a moving cone-conveyor line. Specifically, the system now includes dual robot arms and a new low-cost camera with an integrated image processing method for bird feature detection. Further refinements are underway in preparation for an in-plant trial followed by identifying a potential commercialization partner.
**Full Robotic Processing**
Researchers continued to evaluate the cost and potential benefits of fully automating the poultry deboning process prior to evisceration. A model of the system was developed, and preliminary results indicate that it appears feasible with costs being reasonable given the potential benefits.

**Immunodominant Membrane Proteins (IDPs) Importance as Disease Agents**
Researchers studied plant-pathogenic bacteria like Phytoplasmas to better understand the role of membrane proteins in disease transmission, particularly within plants used in poultry feed. Literature reviews identified bacterial outer membrane proteins, vesicles, and bioactive proteins as key components triggering pathogenic responses due to the surrounding environment. Researchers also identified MALDI/MS (matrix-assisted laser desorption/ionization mass spectrometry) as a promising approach for detecting asymptomatic conditions (i.e., when a disease or disease agent is present without noticeable symptoms) due to its quantitative nature.

**Farm Processing and Transport (FPAT) System**
Researchers continued to evaluate the suitability and economic feasibility of using new technologies for on-farm bird harvesting and related tasks. FY 2019 activities focused on performing an economic analysis of the proposed system compared to current industry practice. Preliminary findings suggest the proposed system, even though it requires larger upfront investment, is an attractive economic choice and will produce sizable economic benefits over the lifetime of the system. An investigation is underway to confirm the findings.

**Dynamic Laser Speckle Imaging for Detecting Living Bacteria**
Researchers designed a rapid and non-contact imaging system that analyzes time-varying granular or speckle patterns in images to identify living bacteria. Initial analyses of experimental time-lapse laser speckle images show clear differences between background and bacteria-grown pads. However, further investigation is needed to correlate the differences with bacteria growth and/or mobility.

**Poultry Product Manipulation**
Researchers developed a prototype automated system that can sense, grasp, and transfer nuggets and fillets from one conveyor to another for further processing. Initial tests showed the system successful in grasping both nuggets and fillets. Further development is underway to demonstrate transferring the products onto a conveyor.

**The Investigation of Bacterial Transport During Secondary Processing (Cross-Contamination)**
Researchers studied the forces associated with bacterial transfer from chicken tissue and processing surfaces. FY 2019 efforts focused on pinpointing areas of possible cross-contamination during secondary processing operations by studying carcass bacterial loads. Six sample locations (breast, leg, cavity, shoulder, back, and tail) and two depths (skin and muscle) were selected from carcasses after chilling. Results indicate that bacteria loads vary depending on the sampling location and depth, with the breast skin showing the highest CFU (colony-forming unit).

**Incorporating Green Technology into Broiler Chicken Growout Houses**
Researchers investigated the feasibility of using renewable energy systems in broiler growout houses. Multiple technologies were identified that could potentially reduce energy usage while also providing secondary benefits like improved productivity and/or profits. These include high-efficiency LED lighting, fully enclosed houses with advanced climate control, solar energy systems, waste management systems, and biomass heating systems.
3D Perception for Bin Picking
Researchers continued to develop a machine learning-based approach to predict a deformable object’s pose and the best way to grasp it for poultry processing tasks like robotic bin picking. During FY 2019, researchers developed the components of the full bin picking pipeline along with the necessary manipulation algorithms. Initial testing proved promising, and further work is underway to develop advanced 3D reasoning for robotic manipulation and improve the robustness of pose estimation and processing of 3D input.

Next Generation Yield and 3D Scanning
Researchers developed a novel 3D reconstruction system using multiple stereo cameras to generate high-fidelity models of live chicken and processed parts. Several tests were conducted using data generated from CT (computerized tomography) scans. Yield estimation tests showed promise in the ability to quantify the amount of meat removed from a carcass by using the volume of the generated models. Most promising was live weight estimation, where a correlation coefficient between 96% and 99% was identified when directly comparing the live weight of a chicken with the volume of the CT scan data.

Antibiotic Resistance in Concentrated Poultry Feeding Operations
Researchers collected and analyzed samples from concentrated animal feeding operations (CAFOs) to understand the impacts on the transfer of antibiotic-resistant genes and organisms in the surrounding environment. Analyses revealed that most of the antibiotic-resistant genes found in environmental samples were resistant to bacitracin. No other significant antimicrobial resistance associations were found between litter and environmental samples. Generally, there has been a significant decrease in antibiotic use in poultry operations over the past three years.
**ADVISORY COMMITTEE**

The Agricultural Technology Research Program is conducted in cooperation with the Georgia Poultry Federation with input from an external Advisory Committee consisting of representatives from leading poultry companies and allied organizations.

**Members**
- Steve Snyder, Claxton Poultry (Chair)
- Matt Nelson, Boehringer Ingelheim
- Randy Segars, Boehringer Ingelheim
- Mark Hamby, Cobb-Vantress
- Bill Crider, Crider Foods
- Michael Carr, Darling Ingredients
- Kelly Horne, Darling Ingredients
- David Wicker, Fieldale Farms
- John Wright, Fieldale Farms
- Paul Breure, Foodmate US
- Scott Hazenbroek, Foodmate US
- Kenneth van der Zalm, Foodmate US
- Joe Cowman, Gainco
- Bill Verner, Georgia EMC
- Gary Funk, Georgia Power
- Ed Harmon, Georgia Power
- Blake Wikle, Gold Creek Foods
- Humberto Hernandez, Habasit
- David Bleth, Harrison Poultry
- David Sewell, Keystone Foods
- Matt Brass, Marel
- John Weeks, Mar-Jac Poultry
- Roger Huezo, Meyn Poultry Processing Solutions
- Wally Hunter, Perdue Farms
- Craig Pugh, Perdue Farms
- Adam Willis, Pilgrim’s
- Mike Gasbarro, Prime Equipment Group
- Kirk Reis, Prime Equipment Group
- Dwayne Holifield, Sanderson Farms
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- Terry Bruce, Tip Top Poultry
- Lisa Blotsky, Tyson Foods
- Steve Schimweg, Tyson Foods
- Juan DeVillena, Wayne Farms
- Russ Dickson, Wayne Farms
- Jonathan Green, Wayne Farms
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