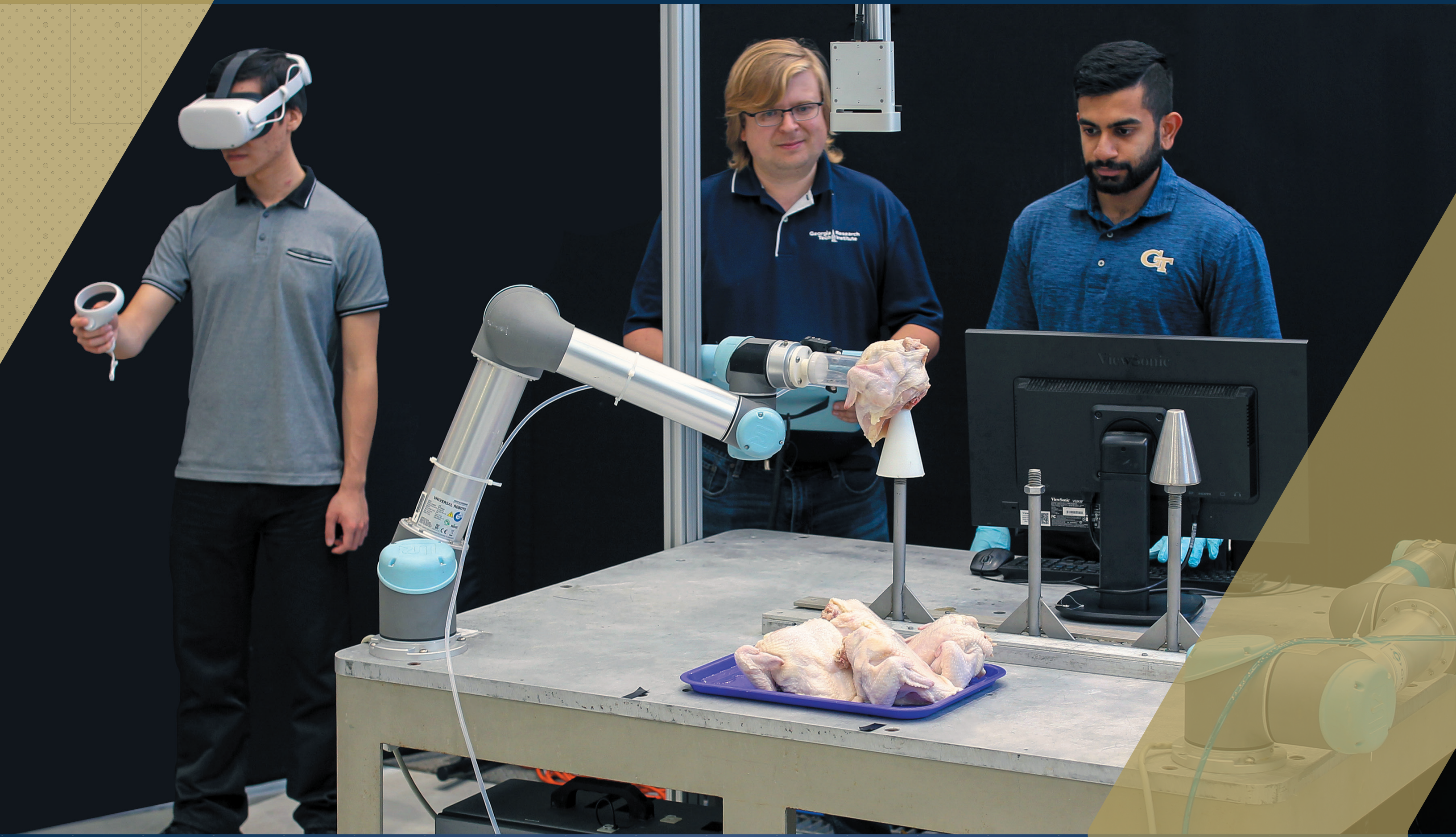
Georgia Tech Research Institute
Agricultural Technology
Research Program

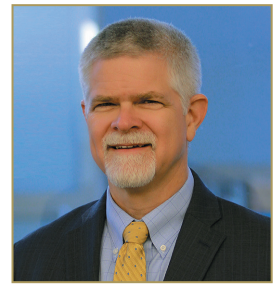


2022 ANNUAL REPORT

TRANSFORMING POULTRY, AGRIBUSINESS, AND FOOD MANUFACTURING THROUGH ADVANCED TECHNOLOGIES

MESSAGE FROM THE PROGRAM MANAGER

Doug Britton, Ph.D., ATRP Program Manager



I am very excited to once again share with you the great work being done in the Agricultural Technology Research Program (ATRP). We continue to focus on exploring a continuum of novel solutions throughout poultry production and processing. These include technologies in environmental treatment, thermal processing, advanced sensing, food safety management, and robotics and automation. Guided by our ATRP vision to transform poultry, agribusiness, and food manufacturing through advanced technologies, we are also seeking to fundamentally rethink certain aspects of the poultry continuum and how new technologies and concepts might drive transformational innovation into the industry.

Our partnerships with industry, other academic institutions, and state and federal labs are key to the success of the ATRP program. We are extremely thankful for these relationships and the generosity of those who dedicate time and resources to work with us as we collectively drive transformational innovation.

On behalf of the entire ATRP team, it is my distinct privilege to share with you this Fiscal Year 2022 Annual Report. Here, you will find summaries of research projects, and get a glimpse of the exciting new technologies and opportunities that we see on the horizon. The future is very exciting, and we invite you to join us on this journey of innovation.

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

Juanfra DeVillena, Wayne Farms (Chair)
Matt Nelson, Boehringer Ingelheim
Randy Segars, Boehringer Ingelheim
Brian Porter, Cantrell-Gainco Group
Steve Snyder, Claxton Poultry
Mark Hamby, Cobb-Vantress
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Adam Willis, Pilgrim's
Dwayne Holifield, Sanderson Farms
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Steve Schimweg, Tyson Foods
Russ Dickson, Wayne Farms
Jonathan Green, Wayne Farms

Advisors

Mike Giles, Georgia Poultry Federation
Abit Massey, Georgia Poultry Federation
Louise Dufour-Zavala, Georgia Poultry Laboratory Network
Todd Applegate, University of Georgia
Denise Heard, U.S. Poultry & Egg Association

FY 2022 PROGRAM HIGHLIGHTS

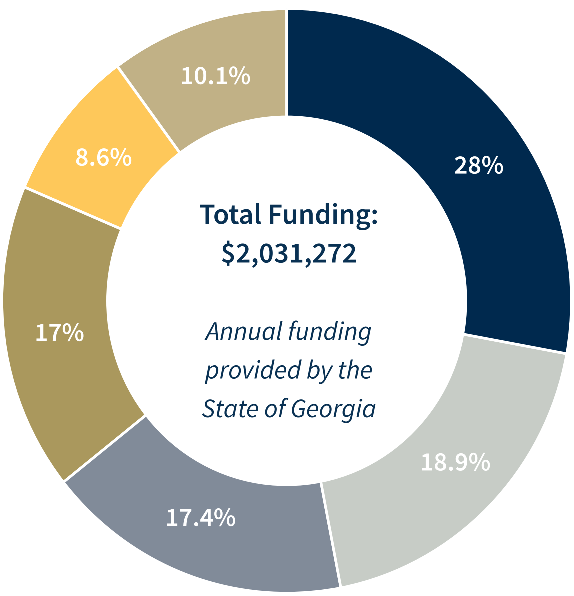
July 1, 2021 - June 30, 2022

By the Numbers

8	4	1	1	5	40	17	MORE THAN 20
RESEARCH PROTOTYPES IN VARIOUS STAGES OF DEVELOPMENT	EXPLORATORY RESEARCH PROJECTS	PROVISIONAL PATENT APPLICATION	FULL PATENT APPLICATION	INVENTION DISCLOSURES	PUBLISHED ARTICLES, PAPERS, AND PRESENTATIONS	PARTICIPATING INDUSTRY AND ACADEMIC PARTNERS	TECHNICAL ASSISTANCE SERVICE REQUESTS FULFILLED

ATRP annually participates in outreach activities, including co-hosting the National Safety Conference for the Poultry Industry with the U.S. Poultry & Egg Association, publishing the PoultryTech newsletter, and coordinating exhibits at the International Production and Processing Expo (IPPE) and Poultry World at the Georgia National Fair.

Financial Summary



Funding Breakdown by Program Area

- Automation and Robotics Research 28%
- Imaging and Sensing Research 18.9%
- Environmental and Biological Systems Research 17.4%
- Technology Transfer/Outreach/Technical Assistance . 17%
- Future Concepts 8.6%
- Program Support 10.1%

Thanks to Our Industrial and Academic Partners

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
Deepchill Solutions
Fieldale Farms
Georgia Power
Harrison Poultry
International Poultry Breeders
Koch Foods
KWJ Engineering
Liquid Ice Technologies
Marel
Mar-Jac Poultry
Perdue Farms
Salvus™
Thor Ice Chilling Solutions
University of Georgia
  College of Veterinary Medicine
  Department of Poultry Science
USDA-ARS U.S. National Poultry Research Center
Wayne Farms

FULL-SCALE RESEARCH PROJECTS

Addressing critical issues facing poultry processing and production

Enhanced Chilling Automation Via Alternative Media and Motion

Background

Typically, during processing chicken carcasses are immersed in screw augers of chilled water, which lowers their core temperature to a degree that inhibits pathogen growth. While effective, the process usually requires carcasses to be removed from a shackle line for immersion. This unshackling results in lost product traceability, product cross-contamination risks, and additional labor needed for subsequent reshackling, known as rehang. To address these concerns, researchers designed and built a laboratory test rig that keeps the carcasses shackled while adding rotational motion. Researchers believe optimized rotation should also magnify the chilling benefit of alternative chiller media like ice slurry.

FY 2022 Research Results

Researchers further investigated the use of advanced motion patterns to enhance in-line immersive chilling in poultry processing. Empirical results demonstrated that rotational kinematics could reduce immersive chilling time of significantly sized WOGs (whole birds without giblets) nominally 25% below that expected with a screw auger and chilled water. Less variation in chilling effect from carcass to carcass was also observed, which alleviates the uncertainty concerns of sporadically under-chilled carcasses when screw augers are used.

On-Farm Processing and Transport (FPaT)

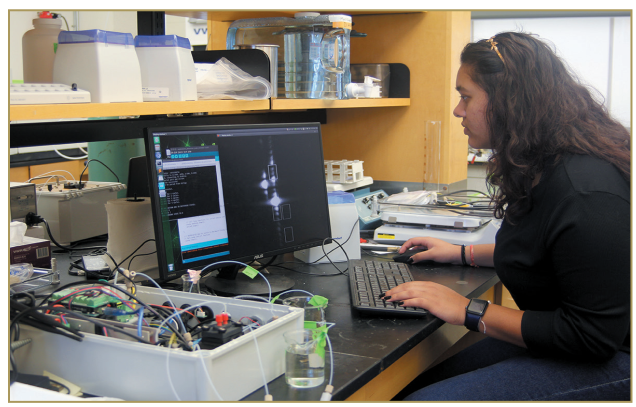
Background

Researchers are evaluating the suitability, effects on processing, and economic feasibility of using a prototype system for on-farm bird stunning, killing, and transport of shackled carcasses. The project reimagines the process of transporting live chickens to processing plants and instead explores processing at the farm. This eliminates live haul transport, minimizes weight loss, and eliminates mortality risks. The system has potential to alleviate bird welfare and well-being concerns associated with live transport while producing economic benefits by reducing manual labor requirements and transportation costs.

FY 2022 Research Results

The team examined the effect of using the FPaT system on carcass processing and meat quality. Experiments did not show major differences between carcasses processed using traditional methods compared to FPaT processing. There was no physical damage to the carcasses transported by the FPaT system, and even though carcasses were in the rigor stage after transport, minimal defeathering issues were observed. Additional tests are needed to fully understand the effects of rigor on further processing of carcasses using the FPaT method. Meat quality analysis also showed similar results between traditionally and FPaT-processed carcasses. pH levels were very similar for both groups.

Integrated Water Management System



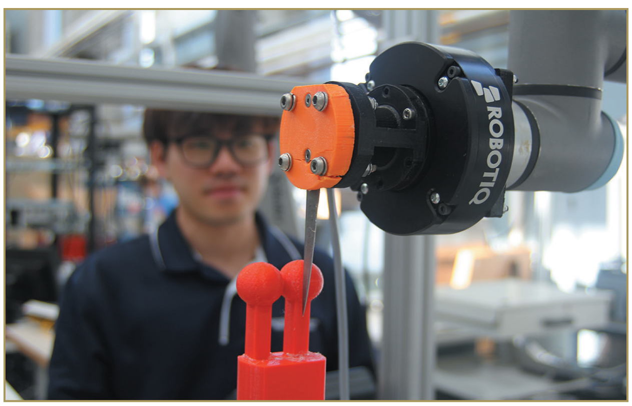
Background

Water quality in poultry processing operations is monitored constantly to maximize water recycling/reuse and optimize wastewater treatment. However, current characterization practices are labor-intensive and require a variety of reagents and testing equipment. Researchers believe full development of an integrated water management system will not only provide a tool for in situ water quality monitoring for wastewater treatment but also enable real-time dynamic tracking of water conditions. This, in turn, will advance the scientific understanding of the fate of contaminants and nutrients in water distribution systems.

FY 2022 Research Results

Researchers continued development of a reagent-free system using an ultrasensitive and multiplexed interferometric sensor for monitoring the amount of the antimicrobial peracetic acid (PAA) in processing water and the amount of fats, oils, and grease (FOG) in processing wastewater. The prototype PAA sensor was field tested at a local poultry processing plant and proved to be sensitive and selective for monitoring in pre-chiller and chiller water, achieving a detection limit below 0.1 ppm with a sensor chip that can used for at least two weeks without fouling. Researchers also investigated a fluorescent-based approach to sense FOG in a clean matrix with concentrations in the range of 10 ppm to 500 ppm. Additional FOG sensing tests are planned.

Advanced Intelligent Cutting



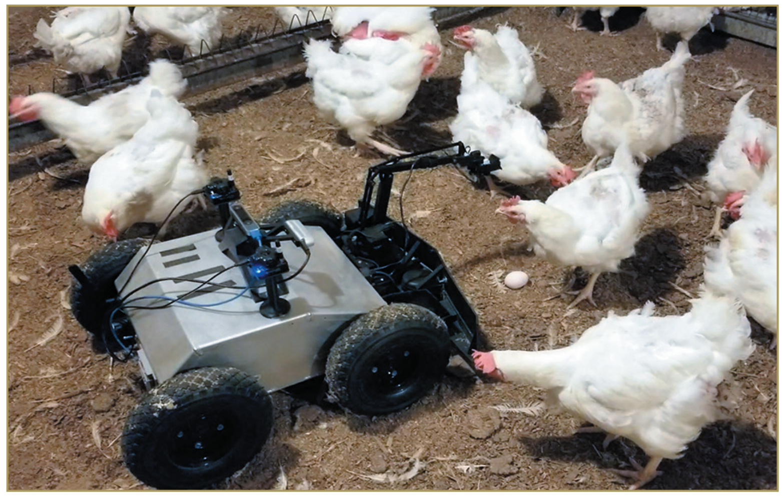
Background

Manual chicken carcass deboning is one of poultry processing's most laborious tasks. Researchers are evaluating the automation of poultry deboning by designing knife trajectories based on learning from expert demonstration (LfD). LfD methods allow expert practitioners (human deboners in this case) to inform/optimize robot knife paths that achieve maximal yield while avoiding bone chips. Researchers believe the approach holds promise for advancing the incorporation of more robotic solutions for manual poultry processing tasks.

FY 2022 Research Results

Previous implementation of automated bird shoulder deboning relied on a single sensing modality (RGB-D) to detect key visual landmarks and subsequently generate a parameterized knife cutting path that is executed open loop. While this approach has proven effective, it lacks robustness and responsiveness. During FY 2022, researchers developed a compliant controller using force feedback. The controller was implemented on a test robot and consists of a model predictive control (MPC), inverse damping control, and a velocity control. Cutting trajectories were successfully tested including cutting around a contour and cutting through a simulated joint model (5 mm deviation).

Growout House Robotics



Background

Researchers are investigating the use of robotic systems to perform broiler and broiler-breeder rearing and management tasks in growout houses. Such tasks include mortality collection, egg picking (in breeder operations), in addition to environmental and animal health monitoring. These tasks are currently conducted with a significant amount of manual labor. Researchers believe robotic systems have the potential to provide growout managers with the capability to collect data for decision support as well as perform utility tasks that can reduce the required labor load while potentially mitigating disease and contamination factors.

FY 2022 Research Results

The research team tested a ground robot that can autonomously navigate poultry houses. Several peripheral features were developed to allow the robot to operate fully autonomously (without a breakdown or human intervention) in a commercial poultry house for two weeks. More field trials in breeder houses are planned to further test and improve the robot's overall operation. The team also outlined a path to commercialization for the robot, with a focus on soliciting conversations with companies or individuals who might be interested in licensing the technology and developing a commercial product.

PAA Decay Kinetics

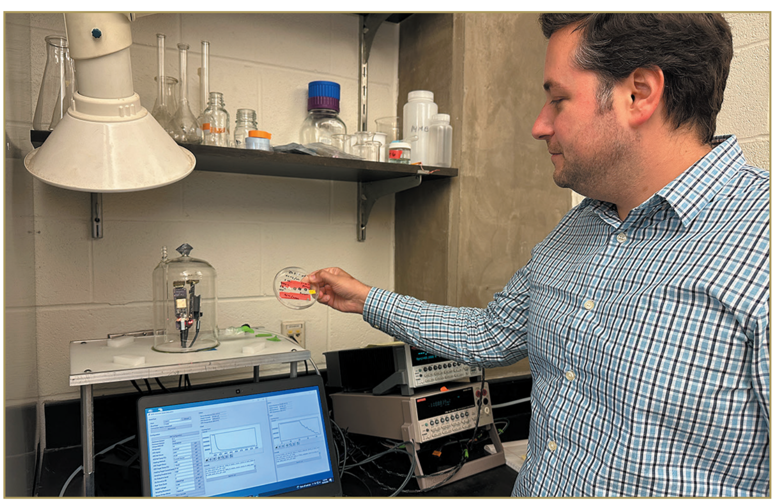
Background

Peracetic acid (PAA) is used as a food safety measure for microbial control in poultry carcass chilling operations. Previous studies have shown that increases in organic carbon may cause PAA concentration to vary dramatically throughout a processing day. Researchers believe a full understanding of PAA decay kinetics in chilling operations will allow processors to optimize water reuse systems and lower the amount of PAA needed for microbial control.

FY 2022 Research Results

Results showed that while individual components of total dissolved solids (cations, protein, lipids, blood) have a small impact on PAA, when they are combined (cations + protein or cations + blood) there is a large effect on the stability of PAA, causing it to have a half-life 20%-30% of its original half-life. (Half-life is the time for half of the starting amount to be consumed or decay). Additional studies showed that pH has an effect on carcass water uptake while PAA does not. This was investigated to understand where the maximum uptake occurs and if PAA has any effect on it. Lower pHs were shown to cause lower water uptake (only ~5.8%), while higher pHs saw higher water uptake (~7.2%). Lastly, researchers further investigated the effects of organic load buildup of both pre- and main chillers on PAA's ability to reduce microbial loads within the chiller. Results were inconclusive, and future work is planned in this area.

Multi-Function Sensor System



Background

Ammonia, resulting from biochemical reactions of chicken droppings in litter, is prevalent in the air of poultry growout houses and must be constantly monitored to maintain safe levels. Most currently available ammonia sensors have short battery life and require frequent recalibration while also suffering from baseline drift, poor selectivity, and false alarms. Researchers believe a durable and depeandable ammonia sensing system with the capability to be integrated into a ventilation system opens a new path to smart and efficient ventilation in poultry farms and improved energy consumption, resulting in a healthier environment for the chickens.

FY 2022 Research Results

Researchers continued development of a low-power electro-thermal gas sensor that exhibits high selectivity, fast response and recovery time, and is capable of real-time monitoring of ammonia levels. During testing, the sensor successfully detected ammonia at 5, 25, and 50 ppm.

Virtual Reality for Robotics System Control and Development

Background

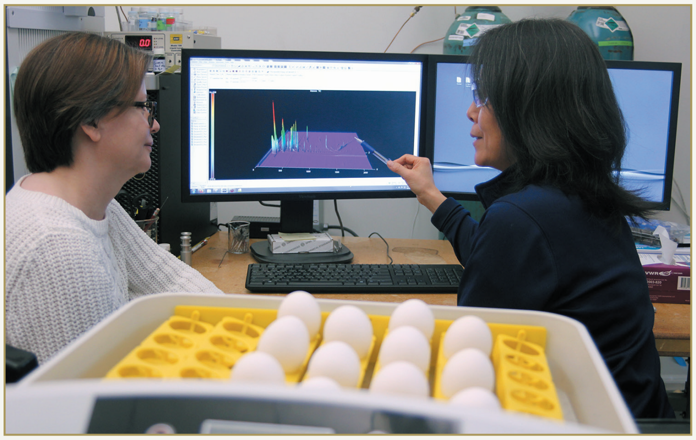
Researchers are exploring virtual reality (VR) systems for aiding the development and deployment of robotic systems in processing environments. Essentially, the human is performing the sensing task, and telling the robot what to do, all from a VR environment. Successful implementation of VR-based systems could alter poultry processing tasks like loading chicken front halves on cones for deboning by removing workers from harsh environments and repetitive tasks.

FY 2022 Research Results

The team created a robust cone loading system that utilizes human decision making with robotic labor to place the front half of a chicken on a cone from a tray. Dozens of successful demonstrations were preformed, including where the VR user was hundreds of miles away and operating in front of a live crowd.

EXPLORATORY RESEARCH PROJECTS

Developing concepts and ideas for later transition into full-scale projects

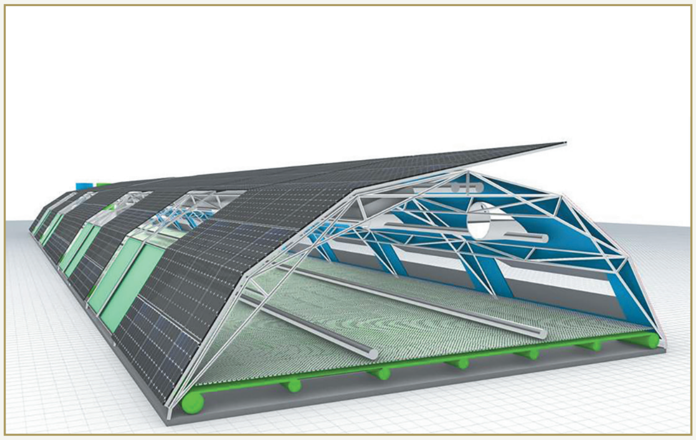


Non-Destructive Egg Fertilization Detection via VOCs

Researchers are using gas chromatograph-mass spectrometry to capture volatile organic compounds (VOCs) from infertile eggs, fertile eggs, and eggs containing female and male embryos to enable early-stage fertility detection and sex identification of eggs. A fast, online, and non-destructive pre-screening of eggs for fertility identification before being passed for incubation would improve hatcher utilization and overall hatch rates, thereby increasing throughput and efficiency of operations. Initial statistical analysis has shown promising classification results on the determination of fertility status (fertile or infertile) through the detection of VOC differences in broiler eggs at a very early incubation time (~ 3 days).

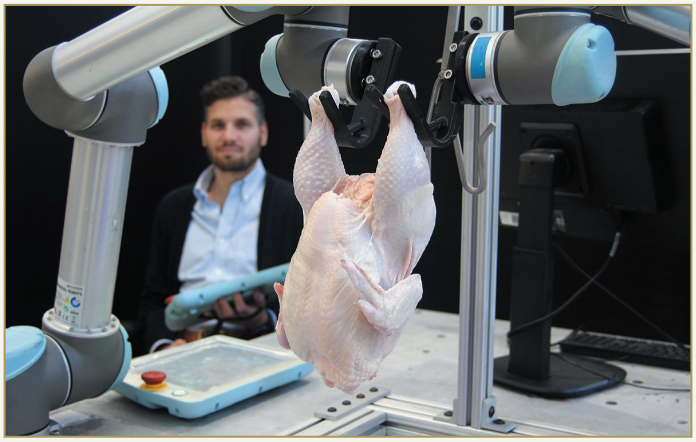
Intelligent Butterfly Trimming

Researchers are exploring ways to increase overall yield and reduce labor in deboned chicken breast (known as butterfly fillets) trimming operations. A prototype semi-automated trimming device was designed that can remove cartilage and bone from the fillets while reducing excess trimming.



Poultry Farm of the Future

Researchers are exploring next-generation poultry house design concepts that are conducive to automation and integrates structural design, behavioral modeling, and operational requirements. The goals are to enable better litter management, reduce energy needs, reduce labor, and be economically viable. Researchers developed several viable concepts, with the most promising version resulting in a fully modeled representation.



Canonical Manipulation

Researchers are exploring the use of advanced image sensing and high degree-of-freedom robotic path planning to create a generalized pipeline for single and multi-arm autonomous robotic manipulation in poultry processing operations. A successful demonstration of the rehang task was accomplished using two robotic arms with simple end effectors to lift a WOG (whole bird without giblets) by its hocks and place it on a shackle. A canonical mapping model aided the robotic arms' predictions of the hocks location for accurate lifting.

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