Date: December 22, 2014

BARD
P.O.Box 6
Bet-Dagan, 50250, ISRAEL

BARD Project No. US-4280-10 R

Project Title

Automated Imaging Broiler Chicksexing for Gender-Specific and Efficient Production

Investigators' Names

Yang Tao

Tom Porter

Amos Mizrach

Victor Alchanatis

N. Shamir

Investigator's Institution

University of Maryland, USA

University of Maryland, USA

ARO, Israel

ARO, Israel

ARO, Israel

Project's starting date: **July 1, 2010**

Type of Report: 1st Annual _____ 2nd Annual _____ **Final X** _____

Signatures:

Principal Investigator

Yang Tao, Ph.D., P.E.

Signature

Institution's Authorizing Official, Principal Institution

1/13/15

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I. Description of Research Activities and Results

Extending the previous two years of research results (Mizarch, et al, 2012, Tao, 2011, 2012), the third year's efforts in both Maryland and Israel were directed towards the engineering of the system. The activities included the robust chick handling and its conveyor system development, optical system improvement, online dynamic motion imaging of chicks, multi-image sequence optimal feather extraction and detection, and pattern recognition.

Mechanical System Engineering

The third model of the mechanical chick handling system with high-speed imaging system was built as shown in Fig. 1. This system has the improved chick holding cups and motion mechanisms that enable chicks to open wings through the view section. The mechanical system has achieved the speed of 4 chicks per second which exceeds the design specs of 3 chicks per second. In the center of the conveyor, a high-speed camera with UV sensitive optical system, shown in Fig.2, was installed that captures chick images at multiple frames (45 images and system selectable) when the chick passing through the view area. Through intensive discussions and efforts, the PIs of Maryland and ARO have created the protocol of joint hardware and software that uses sequential images of chick in its fall motion to capture opening wings and extract the optimal opening positions. This approach enables the reliable feather feature extraction in dynamic motion and pattern recognition.

Fig.1. The prototype of the automated broiler chick gender identification system.

Fig. 2. UV enabled high-speed imaging system on line that captures multi-frames chick opening sequence images when a chick passing through the viewing areas.

Improving of Chick Wing Deployment

The mechanical system for chick conveying and especially the section that cause chicks to deploy their wings wide open under the fast video camera and the UV light was investigated along the third study year. As a natural behavior, chicks tend to deploy their wings as a mean of balancing their body when a sudden change in the vertical movement was applied.

In the latest two years, this was achieved by causing the chicks to move in a free fall, in the earth gravity (g) along short vertical distance. The chicks have always tended to deploy their wing but not always in wide horizontal open situation. Such position is requested in order to get successful image under the video camera. Besides, the cells with checks bumped suddenly at the end of the free falling path. That caused the chicks legs to collapse inside the cells and the image of wing become bluer.

For improving the movement and preventing the chick legs from collapsing, a slowing down mechanism was design and tested. This was done by installing of plastic block, that was printed in a predesign variable slope (Fig. 3) at the end of the path of falling cells (Fig.4). The cells are moving down in variable velocity according the block slope and achieve zero velocity at the end of the path. The slop was design in a way that the de-acceleration become $0.8g$ instead the free fall gravity (g) without presence of the block. The tests showed better deployment and wider chick's wing opening as well as better

balance along the movement. Design of additional sizes of block slops is under investigation. Slops that create accelerations of 0.7g, 0.9g, and variable accelerations are designed for improving movement path and images.

Fig. 3: Block slope for 0.8g de-acceleration. Fig.4: The cell that rides on the slop when at the viewing area.

As shown in Fig.2, the integrated system enables the chick wing opening and imaging processing in the following sections.

Image Pattern Recognition System Engineering

Intensive efforts were made in image processing algorithms to analyze the time-serious 45 frames of sequential images and detect the chick opening wings when chicks in the falling motion in the viewing area. The algorithm is able to perform instantaneous image analysis, allocate the wing feather in coordinates, and select the frame(s) based on the optimal scores of the opening wing feather shafts.

Fig.5 shows a sequence of images from captured 45 frames of a chick in falling motion when passing through the viewing area. Frames 1-5 show the chick is entering the initial falling motion. Notice the wings are still not opened. Starting at Frame 11, the chick wing starts to open, but the feather is not obvious at this time. From Frames 12 to 4, the wings are open. The algorithm automatically identifies opening feathers and allocates them in both local image and global coordinates as shown, and then generates a score of the wing

feather opening quality. The high scores mean the high quality of the opening feathers. As shown in Fig.5, the scores in frames 12, 13 and 14 are 3.628, 4.414, and 3.783, respectively. Through this method, the frame with highest score will be selected for pattern recognition. A minimal threshold $T_{\min}$ can be set to enable the minimal score for the subsequence image processing. If the score $T_{\min}$ is below the predetermined value, it indicates either the wings are not opening or not shown to the camera.

Fig.5. Dynamic image sequence of a chick wing feather opening under its fall motion on the machine and the algorithm automated detection of feathers from image frames.

Fig.6 Continued dynamic image sequence from Frames 20 to 35 of the chick in under its fall motion and the algorithm automated detection of feathers from image frames.

When the chick further falling toward the lower level chain conveyor, the algorithm can still track and detect the opening feathers. Fig.6 shows the frames from 20, 23, and 35, where Frame 23 has a high score of the opening feather. When the chick moves away from the camera in Frame 35, the chick wings retract and the score is low or not given. Frames 43-45 (Fig.7) show the capture of wing feathers again while the chick is flipping its wings and the feathers are detected.

Fig.7 Continued dynamic image sequence of Frames 43-45 where features are captured.

From the motion images of 45 frames, the highest score is 4.414 of the optimal quality, although scores in other frames are good as well.

Fig.8 shows another typical example of chick motion imaging. In this sequence, the chick opening wings at the beginning when it enters into the viewing area as shown in Frames 1 and 5. The wing opens again at Frame 30, which has a score 2.633. Other motion frames are omitted without missing information. The high score for this image sequence would be 3.035 in Frame 1.

Fig.8. Another typical example of chick wing opening and dynamic imaging feather detection.

The chick motion and the moment of its wing opening depends on the chick's sensitivity, activeness, and how fast to react to the fall motion. The timing on when the chick opens its wings varies from chick to chick. Therefore, the method to detect and select optimal scores offers the solution to the variations among chicks and ensures the detection of opening wing feather(s) at the optimal extend.

Bathes of chick samples were taken and resulted in the similar results as shown above. Based on the genetics of fast feathering breeds, female chicks generally have longer feathers than male ones at the same age. The male's short feather can be used as a heuristic as male chick.

In sectional summary, the mechanical and software engineering work successfully for the proposed project. In machine development for a commercial machine, it often requires further investment to advance to field prototype, which requires additional funds for materials, fabrication, and labor. The estimate productivity of this machine having a capacity of 4 chicks/sec/lane, i.e. 14,400 chicks/hr/lane is equivalent to 5.53 people (the speed for manual sorter is 2,600 chicks/hr). The machine can easily be expended to multiple lanes, i.e. a wider machine. A single 4 lane machine will be equivalent to 22 people in labor savings, which would be \$338,250/yr (22 people x 2,052 hrs/year x \$7.5/hr). Generally, the fund for delivering a one-year payback machine at this scale would be a few times of the fund necessary.

II. Evaluation of Research Achievements

In addition to the listed achievements in prior years, the new achievements include:

1. The new mechanical prototype of the machine accomplished enables the broiler chick handling and feather presentation in the view area.
2. The improved UV sensitive optics and high-speed camera that captures synchronized chick motion images.
3. The prototype machine enable chick wing opening as expected reliably.
4. The dynamic imaging algorithm is able to perform instantaneous image processing of 45 image frames and detect opening wing feathers for each chick in fall motion in the viewing area.
5. The algorithm can further allocate the wing feather and generate scores for selecting optimal wing feather pattern from the sequence of motion images of chick from entrance to the exist of the view area.
6. Both mechanical system, and electronic imaging algorithm software showed effectiveness in performing the tasks of chick sex identification.
7. Presented results in CIGR internal conference.
8. In contract and working with local Israeli company for the prototype development and commercialization.

III. Description of Cooperation

The cooperation between Israel and Maryland during the project have been through on-sites meetings, design discussions, tele-data sharing, result analyses, and teleconferences.

- PIs had the project meeting at UMD to exchange information and gain knowledge for the development toward the next stage of the system.

Fig. 9. PIs (Drs. Tao, Chen, and Mizrach) discuss the project at the University of Maryland.
Left: At the conceptual test model in Bioimaging and Machine Vision Lab at UMD;
Right: Result discussion meeting at the Yang's office. August, 2012.

- PIs had the project meeting at ARO to discuss the prototype development and future planning. Dr. Yang Tao gave a presentation to the faculty and staff at ARO, where Drs. Amos Mizrach and Victor Alchanati demonstrated the lab prototype unit under development.

Fig.10. PIs discuss the project at the Institute of Agricultural Engineering, at Volcani Center ARO, Israel. April, 2014

- Exchange of information through teleconferences and internet server on the approaches, design solutions, data exchange, result discussions. Various aspects of the methods were discussed throughout the project development.

IV. Conclusion and Post Project Plan

Through intensive research efforts by PIs at both UMD and ARO, we have successfully developed a lab prototype and have delivered the engineering R&D machine as far as we can for the given time and budget. The prototype contains all the necessary technical data and results that have the potential to be further invested toward the commercialization.

The PIs have discussed to file a patent for the technology and have contacted with patent offices of both UMD and ARO.

Furthermore, Drs. Amos Mizrach at ARO has contacted an Israel company which is interested in manufacturing the machine for commercialization. The PIs will continue to communicate and develop the technology.

V. Publication:

Mizrach, A., Victor Alchanatis, Nachshon Shamir, Viacheslav Ostrovsky, Clara Shenderey, Asher Levi, Yang Tao, Thomas Porter, and Xin Chen. 2012. Development of Chicks Handling System to Enable Automated Broiler Feather Sexing. ASABE Annual Meeting, Dallas, Texas. July 2012. ASABE paper Number: 12-1340567.

Tao, Y. A. Mizrach, V. Alchanatis, and X. Chen. Machine Intelligence and Automation for Improved Productivity, Quality, and Profit - Broiler Chick Gender Sorter. CIGR International Conference. Invited section keynotes. Beijing, September 17, 2014.

Patent pending....

VI: Acknowledgement:

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