Spectators on a mechanical harvesting tour in 2000 watch a harvester at work in a southwest Florida grove. Robotics may play a major part in citrus harvesting in years to come.

ROBOTS in our future

By Walt Kender

Kentucky native Tom Burks heads the University of Florida citrus robotics research and development program. He received a B.S. in agricultural engineering from the University of Kentucky (UK) in 1978, then worked for seven years in Nebraska with Chief Industries, Inc., a manufacturer of grain storage and handling equipment.

He returned to UK in 1985 to earn concurrent MS degrees in agricultural and electrical engineering, specializing in robotics and controls. From 1989-92, Burks worked for FMC Corporation in Madeira, Calif., conducting research and development for food processing equipment controls, including the robotic Automated Batch Retort System.

He returned to UK again in 1993 to complete his Ph.D. and post-doctoral research in machine vision systems, instrumentation and neural networks.

Consider the serious dilemma the Florida citrus industry would face if the harvest labor force became unavailable in the future. For the past eight years, the Florida Department of Citrus (FDOC) has, in fact, addressed this issue head on through the efforts of the Citrus Harvesting Research Advisory Council.

Because cost reductions in production and marketing are needed to increase profitability, the thrust of the harvesting program is to reduce the high cost of harvesting so Florida citrus can be competitive in world markets.

Mechanization of fruit removal from the tree to the processing plant has emerged as a high priority research issue. The FDOC program, headed by Harvesting Program Administrator Galen Brown, continues to make steady progress in overcoming future harvesting barriers in Florida.

Five economically-viable harvesting systems are being used for commercial harvesting of citrus in the state. Thirty units will harvest an estimated 20,000 acres of oranges for processing in 2002-2003. It is imperative to rapidly increase this acreage over the next few years to build momentum for a statewide adoption of mechanized harvest operations.

The trunk shake and catch and the continuous canopy shake and catch systems presently show the most promise for future use. According to Brown, production cost savings for these systems now can range from 10-25 percent. Future refinements in the harvest system used, grove conditions, scheduling of fruit delivery and the maximum harvester capacity will increase the level of production cost savings.

ROBOTS: WHY NOT CITRUS ?

A recently-initiated program funded by the FDOC is exploring the use of robotics for citrus harvest. Thousands of manufacturers utilize robotic systems for a diversity of operations ranging from automobile assembly to greenhouse flower production. Why not for picking oranges?

Initial interest in the robotics concept, also referred to as "Agmechtronics," goes back to the 1980s in Florida when Roy Harrell, University of Florida agricultural engineer, started a successful program demonstrating that citrus fruit could be detected and removed from the tree by automated operations. Unfortunately, because of a lack of financial support, the technology was never developed for commercial use. Later research efforts in the 1990s by Italian, French, Japanese, Spanish and Israeli engineers attempted to further develop robotic picking of oranges for fresh markets using digital machine vision cameras and computers to search for orange color and shape in the canopy. For various reasons, these programs were also discontinued.

As we ushered in a new millennium, a renewed interest in automated robotic citrus harvesting had begun. Two years ago, the Department of Agricultural and Biological Engineering at the University of Florida in Gainesville hired a new Ph.D. robotics specialist. Tom Burks, a native of Kentucky, was given the responsibility to develop a robotics research and development program.

To better explore the feasibility for automated citrus harvesting, a fact-finding team was organized by Brown and the FDOC during the summer of 2001. The team evaluated the state-of-the-art agricultural robotics, paying particular attention to past successes and failures. This exercise was followed by a robotics technology forum held in 2002 consisting of 32 experts from various fields to get their advice before moving ahead. The consensus of the panel was that there had been sufficient advances in technology during the past decade to justify a renewed development effort in robotic citrus harvesting. An additional conclusion of both the fact-finding team and the forum was that a sustained long-term research program was needed. Such a program would require substantial funding levels from both state and federal sources.

The feasibility of collaborating with other tree fruit associations such as apple, citrus, peach and pear was suggested to stimulate a national initiative. With this support, Burks submitted a proposal to the FDOC to begin a more aggressive research initiative into the feasibility of robotic citrus harvesting.

Earlier robotic citrus harvesters were deficient in two major areas. First, too many fruit were left on the tree after harvest (lack of efficiency), and secondly, the robot was not fast enough (not enough labor productivity gain). It was clear to Burks and the team that before a prototype should be built, past problems should be solved and new technologies should be integrated into a complete system.

Burks sees this as a seven- to 10-year development program, which will include participation from academic and federal research agencies, industry and consultants. His plan of attack is three-fold. First, "overcome old problems in the first three to four years, then proceed into an R&D (research and development) prototyping phase which may run from years four through seven. The third and final phase is a joint program with researchers, manufacturers and the citrus industry to bring forth a market-ready harvesting system." His objective is to improve fruit identification and removal on the surface and within the tree canopy, achieving a 90-percent-plus harvesting efficiency. (Note: The French robotic system was able to gain only 70-75 percent harvest efficiency).

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TREE TRAINING

Burks is collaborating with Bill Castle, Adair Wheaton and other researchers at the Citrus Research and Education Center at Lake Alfred to determine the horticultural aspects that will facilitate the robotic harvester and allow it to get a high percentage of the fruit in the canopy. In short, they concurrently are trying to adapt the tree to the needs of the harvester, and fitting the machine to the existing production system.

This philosophy will require major changes in grove management strategies. Citrus tree training, particularly hedgerows no more than 12-15 feet in height with a narrow in-row canopy width, to position the fruiting zone on the outer edges of the hedgerow, will be required for optimum operation of the robotic harvester. Economic models are being developed by Fritz Roka, economist at the Southwest Florida Research and Education Center in Immokalee.

FUNDING

The use of robotics to harvest citrus currently is being addressed only in Florida. Most commodity groups cannot afford the cost for such a project. Although the FDOC is supporting Burks' work, it will take a national effort including other tree fruit such as apples, pears and peaches to convince the USDA and other federal agencies to provide the level of funds necessary to develop and sustain such an R&D program. Burks believes that "it is important for the Florida citrus industry to help raise the awareness of the USDA for the need for the automation of tree fruit crops, especially citrus."

The Florida Citrus Robotics Harvesting program is a long-term program which, to be successful, must be sustained at an appropriate budgetary level. If such funding is provided, the technical barriers will no doubt be overcome.

COOPERATION NEEDED

Burks is a strong proponent of cooperative research and anticipates a collaborative research effort between several scientific disciplines. There will, of course, be the work of the horticulturists and postharvest engineers at Lake Alfred. He also plans to bring together a team of researchers from UF-Gainesville and Oak Ridge National Laboratories, Manufacturing and Consulting, to help tackle the technical challenges posed by robotic harvesting.

THE FUTURE OF ROBOTICS: POINTS TO PONDER

- Will adequate resources be available to sustain such an R&D program at the state or federal level?
- Can existing groves be robotically harvested without drastic cultural changes?
- The tree is just as important as the engineering mechanisms. Will citrus growers be willing to make grove management changes to adapt their trees to automation?
- Will custom harvesters be willing to invest in expensive robotic equipment?
- What is the cost of the equipment? Can there be an early economic payback?
- Will abscission agents be needed?
- Can a robot harvester be developed with multiple arms, which each pick fruit at one fruit per second or faster?
- What is the maximum percentage of the crop that can be harvested by robots and still achieve economic payback?
- How soon can research data be available to determine cost projections, performance criteria, fruit detection systems and optimum design?

When these questions are satisfactorily answered, citrus growers of Florida should be optimistic that robots may indeed be in our future. Until then, we must place our full confidence in Burks and his colleagues.

An additional point to ponder: Will robots some day replace our scientists?

We hope not!

Kender is a retired University of Florida scientist and former director of the Citrus Research and Education Center at Lake Alfred.