areas, hospitals, public areas, and air quality surveys. A patent application has been filed for the ESD, and it is available for licensing.

Robot Synergy: A Marriage of Engineering and Biology

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The Agricultural and Biological Engineering Department of the University of Illinois is pioneering agricultural robotics by integrating concepts from biology and engineering. As a starting point, AgTracker was developed — a rugged, simple, skid steering robot at a manufacturing cost of $500. The main objective of this robot was to demonstrate low-cost crop guidance functionality.

In pursuit of using the synergy among multiple, communicating robots, AgAnts were built. Imagine an AgAnt roaming the field looking for weeds. When a weed plant is detected, the lone AgAnt "calls in the cavalry" to tackle the patch as a group. Similar to real ants, the combined intelligence of the AgAnts army allows for advanced strategies. This would require learning among robots or intelligence evolution, to "grow" the optimal weed management strategy rather than designing one. Even mechanical robotic reproduction comes to mind, but implementation would be a challenge.

AgTracker, a rugged, simple, and inexpensive robot for scouting applications.

The mechanism behind intelligence evolution might be realized as intelligence replication, where virgin robots (or recycled underachieving ones) with blank brains are "educated" using the combined "wisdom of weeding" of two or more successful parents. This evolving robotic ecosystem within a biological one would be a genuine engineering marvel based on the theoretical framework developed by bio-mathematicians and a celebration of the As and B in ASABE.

AgAnt, a thought provoker to illustrate the concept of a mechanical ecosystem within a biological one.

The idea goes further. Imagine making the natural in-situ resources, such as the weeds, the energy source of the AgAnts. This may sound far-fetched, but recently the University of Western England launched Ecobot II, a flying robot that eats flies for lunch. Along the same line, the Agricultural and Biological Engineering Department is developing an autonomous harvester for Miscanthus, an energy crop, recently introduced in Illinois. Similar to Ecobot II, the robot is powered by the logical, locally available energy source, the Miscanthus crop itself, using a Stirling engine as an energy converter.

The viability of automation technology in agriculture can be demonstrated by building the Autonomous Acre. The project goal is to grow a crop without human intervention. This requires autonomous machinery for tillage, planting, fertilization, scouting, spraying and harvesting, and most importantly, the addition of intelligence to the machines so they can make management decisions that optimize crop yield and minimize environmental impact.

The concept could come full circle by building a bio-based living arrangement where the farming operations are automated and integrated with the living spaces, waste management, animal housing, energy generation, water treatment and housekeeping. This approach utilizes the synergy among robots and to brings together automation, culture, environment, and systems (ACESys), creating a sustainable life support system for current and future generations.

Modular Design Makes Smart Transducers Plug-and-Play Possible

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As an increasing number of microcontrollers, sensors, and actuators are embedded in agricultural machines and processes, efficient system integration becomes a critical issue. A recently developed agricultural bus standard, ISO 11783, provided a platform for mobile equipment communications through controller area networks (CAN), enabling plug-and-play of microcontrollers of different makes, types, and models. However, plug-and-play installation of sensors and actuators remains an unsolved task.

Standardization efforts initiated by the National Institute of Standards and Technology led to the development of IEEE 1451.1-5, the standards for intelligent sensors and actuators,