Optimal Orchard Architectures for Optimal Robot Manipulators

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With the global population expected to reach 9 billion by 2050, agricultural production must double to meet the demand. Due to the limited resources (water, land, and labor), the efficiency of agriculture production must increase in efficiency by at least 25%. In the last few decades, we have seen impressive progress in agricultural mechanization in field crops but less in specialty crops.

Even more than other industries, the budget constraints in agriculture are tight, hence the motivation to find the simplest (and cheapest) robot to fulfill a task. This calls for a task-specific robot optimization. In this talk, I will specifically discuss our efforts to define and perform such task-based optimization for an apple-harvesting robot. Since there is a large variation between trees, instead of performing this laborious optimization on many trees, we look for a "lower dimensional" characterization of the trees. Moreover, the shape of the tree (i.e., the environment) has a major influence on the robot's simplicity. Therefore, we strive to find the best training system for a tree to help simplify the robot's design. In our early work on this topic, we have simulated a variety of orchard architectures and searched for an optimal robot design for each architecture. From the training systems that we considered, the Tall Spindle system provides the minimal average time for fruit picking and thus is preferable, not for humans, but for robotic harvesters.

In the **C**ivil, **E**nvironmental, and **A**gricultural **R**obotics (**CEAR**) Lab at the Technion, we design different types of autonomous robots for agricultural tasks, from monitoring to harvesting. If time permits, I will discuss some ongoing projects.

Most of the work presented in this talk is of the PhD student Victor Bloch co-advised by me and Dr. Avital Bechar from the Agricultural Research Organization.

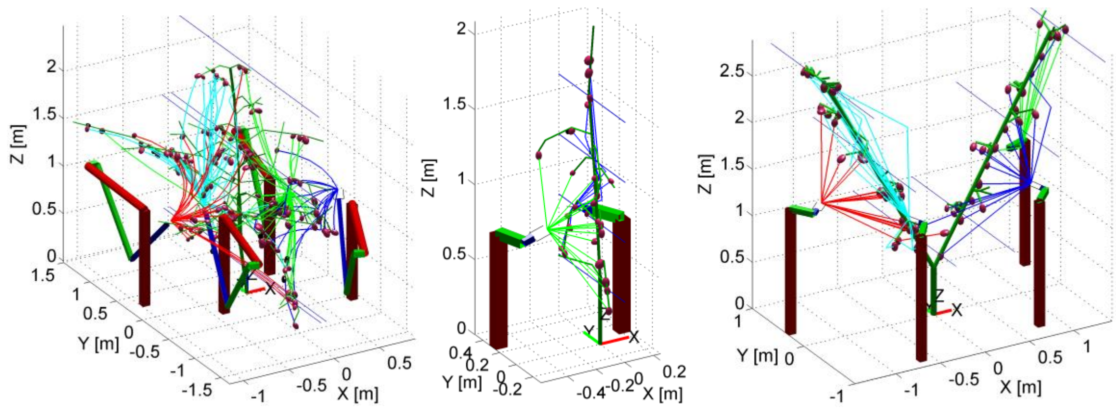

Fig. 1: Optimal robots and their end-effector trajectories for Central Leader (left), Tall Spindle (middle), and Y-trellis (right) apple trees.

Bio: Dr. Amir Degani received the B.Sc. degree in mechanical engineering from the Technion—Israel Institute of Technology, Haifa, Israel, in 2002 (summa cum laude) and the M.S. and Ph.D. degrees in robotics from Carnegie Mellon University, Pittsburgh, PA, USA, in 2006 and 2010, respectively. Since 2011, he has been an Assistant Professor with the Faculty of Civil and Environmental Engineering, Technion. He is the Director of the Civil, Environmental and Agricultural Robotics (CEAR) Laboratory researching robotic legged locomotion and autonomous systems in civil and agriculture application. His research interests focuses on mechanism analysis, synthesis, control and motion planning and design with emphasis on minimalistic concepts and the study of nonlinear dynamic hybrid systems. Prof. Degani has five patents in the robotics field and he has received the Best Paper Award at the IEEE BioRob Conference in 2006, the Best Video Award at the IEEE ICRA Conference in 2010, and the JTCF novel technology paper award in IEEE IROS 2015.