

**Application for Innovation Fund
First Set of Proposals Due: June 24th, 2016**

- Name and contact information for primary person on the project

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- Project Plan title and number

Nondestructive quality assessment and grading of fruits and vegetables

- Project Plan summary

Production cost and postharvest quality are major concerns for U.S. specialty crop industries. Development and deployment of appropriate nondestructive quality grading and tracing technologies for harvesting and postharvest handling has great potential to enhance production efficiency, product quality, and thus profitability for the specialty crop industries. Recent research has demonstrated that optical measurement and characterization can provide the most effective means for nondestructive property and quality assessment of horticultural and food products. The overall goal of the research is therefore aimed at developing new methods and technologies for accurate and efficient quality assessment and grading of fruits and vegetables at harvest and during postharvest handling. Specifically, innovative optical sensing methods and techniques will be developed for accurate measurement of properties and internal quality/maturity of fruits and vegetables. New, cost effective, automated sorting technology will be developed and transferred to fruit growers for harvesting, sorting and grading apples in the orchard. The research objectives will be accomplished by using a systems approach of integrating property characterization and sensors and algorithms development, and through creative utilization of the latest knowledge and technology in imaging, spectroscopy and computer, coupled with advanced mathematical and statistical data processing and analysis methods. The new knowledge and technologies generated from the research will enable growers and packers/processors to more efficiently manage harvest and postharvest operations so as to achieve production cost savings, enhance product marketability, and reduce postharvest product loss.

- Project Plan objective

The overall goal of the research is to develop new methods and technologies for accurate and efficient quality assessment and grading of fruits and vegetables in orchard and during postharvest handling, so as to help specialty crop growers and processors reduce production cost and postharvest loss, and ensure high quality, consistent products for the consumer. A systems approach of integrating sensors development, properties characterization, and algorithms development will be applied to attain the following specific objectives:
Objective 1: Enable new commercial imaging and spectroscopic methods to determine fruit and vegetable internal quality and maturity.
Objective 2: Enable new, economical, accurate, automated, in-orchard methods for commercial apple quality tracing and grading.

- Name(s) and contact information of member(s) on Project Plan Team

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- A brief description of the stage of development of the research and/or technology

We have developed a cost-effective and commercially viable technology for apple harvesting and automatic sorting in the orchard. We have designed, and are in the final stage of assembling, the first commercial self-propelled apple harvest and automatic sorting prototype, which incorporates the harvest aid function with our new, innovative, and cost-effective computer vision-based technology for automatically sorting and grading apples into two or three quality grades (i.e., cull, processing, or fresh). The sorting system is modularly designed for easy mounting or adaptation to the self-propelled apple harvest platform designed by our team and other commercial harvest platforms. We have also designed and assembled a new apple bin handling system for automatic, continuous handling of empty and full bins without causing disruption to the harvest crew, thus significantly improving the overall harvesting operation efficiency. Finally, we have established a formal cooperative agreement with Precise Manufacturing, Inc., a horticultural equipment manufacturer in Michigan, to expedite the development and transfer of our technology to the U.S. apple industry. The self-propelled apple harvest and automatic infield sorting prototype will be ready for demonstration and evaluation in a commercial orchard during the 2016 harvest season.

- A brief description on how the requested funding will enhance the commercial potential of an agricultural solution currently under development in the Project Plan and/or enable the adoption of the Project Plan's research outcomes by industry, academia and other stakeholders.

The requested funding will be used for further improvement, test and evaluation of the commercial apple harvest and automatic sorting prototype to better meet the needs of the U.S. apple industry and expedite the transfer of the technology for commercial use. We intend to use the funding: 1) to improve the usability and reliability of the computer vision-based sorting system that has been developed by our research team, and 2) to test and evaluate the new commercial prototype under different orchard structures for a variety of apple cultivars. Although the developed apple grading and sorting system can meet the basic requirements of grading and sorting apples in the orchard, it needs further improvement in its user-interfacing functions and its reliability of operation in the commercial orchard environment. Specifically, improvements will be made for the computer vision-based sorting program so that it would require as little time and effort as possible from the harvest workers to operate the system. Moreover, because the sorting system will be operated under the rugged, harsh orchard environment, it would be vulnerable to a number of environmental and operational factors (i.e., temperature, humidity, dust, vibration, steep slope, etc.). Hence, it is important that extensive testing be done for the apple harvest and sorting machine operated under various orchard conditions for different apple cultivars in order to more fully evaluate the performance of the new machine for harvesting and sorting apples. This step is critical for the adoption of the developed technology by a wide range of apple growers in the U.S.

- A brief description of the regulatory and intellectual property considerations to adopt research outcomes.

No regulatory considerations are expected in the adoption of the research outcomes. The research has so far resulted in the filing of three invention disclosures, which include: 1) Docket No. 70.16, entitled "Device and system for sorting apples in the orchard," 2) Docket No. 141.16, entitled "Systems for apple harvesting and automatic infield sorting," and 3) Docket No. 142.16, entitled "Apple harvesting system." The invention disclosure No. 70.16 has been approved by the ARS Mechanical and Measurement Patent Committee in March 2016, while the other two invention disclosures are pending on review by the Committee at its June meeting. The three inventions are co-owned by ARS and Precise Manufacturing, Inc., a commercial partner for the research project.

- A brief description of whether the project is composed of a team with cross-functional expertise across multiple national programs, areas of science, geographic areas, and/or members from other research organizations or companies.

The project involves a team of members with multi-disciplinary expertise in biosystems and agricultural engineering, imaging and electronic engineering, and horticulture. We are currently partnering with Precise Manufacturing, Inc. in Michigan to commercialize the developed technology. An advisory committee was formed for the project in 2015, which consists of six members representing apple growers, extension specialists, packinghouse and equipment manufacturer. Since 2015, the advisory committee has met with the research team at least five times to review and discuss the progress of the project and provide inputs and suggestions on the overall direction of the project. The project team is also collaborating with researchers and extension specialists at Michigan State University and Washington State University's Center for Automated and Precision Agricultural Systems for testing and evaluating the apple harvest and sorting machine in commercial orchards in Michigan and Washington, two leading apple producing states in the U.S.

- Innovation Fund application requires approval from RL, CD, AD & NPL prior to submission.

RI - Renfu Lu

CD -

AD - *Amor*

NPL - *Gene Lester*

GENE LESTER 6/21/16