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3-D Imaging Systems

Basic Principle	Sensor/Technique	Advantages	Disadvantages
Triangulation	Consumer triangulation sensor (CTS)	-Off-the-shelf -Low cost -Provide RGB stream -Good community support, good documentation -Open source libraries available	-Vulnerable to sunlight, where no depth information is produced -Depth information is not possible at night or in very dark environments -Not weather resistant -Warm-up time required to stabilize the depth measurements (~1 h)
	Stereo vision	-Good community support, good documentation -Off-the-shelf smart cameras (with parallel computing) available -Robust enough for open field applications	-Low texture produce correspondence problems -Susceptible to direct sunlight -Computationally expensive -Depth range is highly dependent on the baseline distance
	Structure-from-motion	-Digital cameras are easily and economically available -Open source and commercial software for 3-D reconstruction -Suitable for aerial applications -Excellent portability	-Camera calibration and field references are a requirement for reliable measurements -Time consuming point cloud generation process is not suitable for real-time applications -Requires a lot of experience for obtaining good raw data
	Light sheet triangulation	-High precision -Fast image data acquisition and 3-D reconstruction -Limited working range due to the focus -Do not depend on external light sources -New versions have light filtering systems that allow them to handle sunlight	-High cost -Susceptible to sunlight -Time consuming data acquisition
TOF	TOF camera	-Active illumination independent of an external lighting source -Able to acquire data at night or in dark/low light conditions -Commercial 3-D sensors in agriculture are based on the fast-improving photonic mixer device (PMD) technology -New versions have pixel resolutions of up to 4.2 Megapixels -New versions have depth measurement ranges of up to 25 m	-Most of them have low pixel resolution -Most of them are susceptible to direct sunlight -High cost
	Light sheet (pulse modulated) LIDAR	-Emitted light beams and are robust against sunlight -Able to retrieve depth measurements at night or in dark environments -Robust against interference -Widely used in agricultural applications -Many research papers and information available -New versions perform well in adverse weather conditions (rain, snow, mist and dust)	-Poor performance in edge detection due the spacing between the light beams -Warm-up time required to stabilize the depth measurements (up to 2.5 h) -Normally bulky and with moving parts -Have problems under adverse weather conditions (rain, snow, mist and dust)
Interferometry	Optical coherent tomography (OCT)	-High accuracy -Near surface light penetration -High resolution	-High cost -Limited range -Highly-textured surfaces scatter the light beams -Relative measurements -Sensitive to vibrations -Difficult to implement

Title	3-D Imaging Systems
Title (native language)	
Category	• Controlled traffic technology • Robot or smart machine
Short summary for practitioners (Practice abstract) in English)	Currently, 3-D sensors are becoming smaller, smarter, and cheaper. Therefore, technology breakthroughs are already possible if enough research were commercialized, a statement justified by the fact that some commercial implementations in agriculture are mentioned in this paper. The structure of this paper consists of an overview of the different optical 3-D vision techniques based on the basic principles. Afterwards, their application in agriculture is reviewed. The review specifically focuses on vehicle navigation and crop and animal husbandry. The depth dimension brought by 3-D sensors provides key information that greatly facilitates the implementation of automation and robotics in agriculture. Reasons like reduced labor availability, scarcity of natural resources, and consumer demand for quality products are driving the need for automation in agriculture.
Short summary for practitioners	
Website	
Audiovisual material	
Links to other websites	
Additional comments	
Keywords	Agricultural production systems | Farming equipment and machinery | Plant production and horticulture
Additional keywords	3-D sensors, optical triangulation, time-of-flight, automation, robotics

Geographical location (NUTS)	EU
Other geographical location	
Cropping systems	
Field operations	Crop and soil scouting
SFT users	Farmer | Contractor | Supplier | Buyer | Processor
Education level of users	All
Farm size (ha)	0-2 | 2-10 | 10-50 | 50-100 | 100-200 | 200-500 | >500

Scientific article

Title	3-D imaging systems for agricultural applications—a review
Full citation	Vázquez-Arellano, M.; Griepentrogv, H.W.; Reiser, D.; Paraforos, D.S. (2016). Sensors (Switzerland), DOI:10.3390/s16050618

Effects of this SFT

Productivity (crop yield per ha)	No effect
Quality of product	No effect
Revenue profit farm income	No effect
Soil biodiversity	No effect
Biodiversity (other than soil)	No effect
Input costs	No effect
Variable costs	No effect
Post-harvest crop wastage	No effect
Energy use	No effect
CH4 (methane) emission	No effect
CO2 (carbon dioxide) emission	No effect
N2O (nitrous oxide) emission	No effect
NH3 (ammonia) emission	No effect
NO3 (nitrate) leaching	No effect
Fertilizer use	No effect
Pesticide use	No effect
Irrigation water use	No effect
Labor time	Some decrease
Stress or fatigue for farmer	Some decrease
Amount of heavy physical labour	Some decrease
Number and/or severity of personal injury accidents	No effect
Number and/or severity of accidents resulting in spills property damage incorrect application of fertiliser/pesticides etc.	No effect
Pesticide residue on product	No effect
Weed pressure	No effect
Pest pressure (insects etc.)	No effect
Disease pressure (bacterial fungal viral etc.)	No effect

Information related to how easy it is to start using the SFT

This SFT replaces a tool or technology that is currently used. The SFT is better than the current tool	no opinion
The SFT can be used without making major changes to the existing system	no opinion
The SFT does not require significant learning before the farmer can use it	no opinion
The SFT can be used in other useful ways than intended by the inventor	no opinion
The SFT has effects that can be directly observed by the farmer	agree
Using the SFT requires a large time investment by farmer	no opinion
The SFT produces information that can be interpreted directly	no opinion

View this technology on the Smart-AKIS platform

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