



3D Vision-based Shelf Monitoring System for Intelligent Retail

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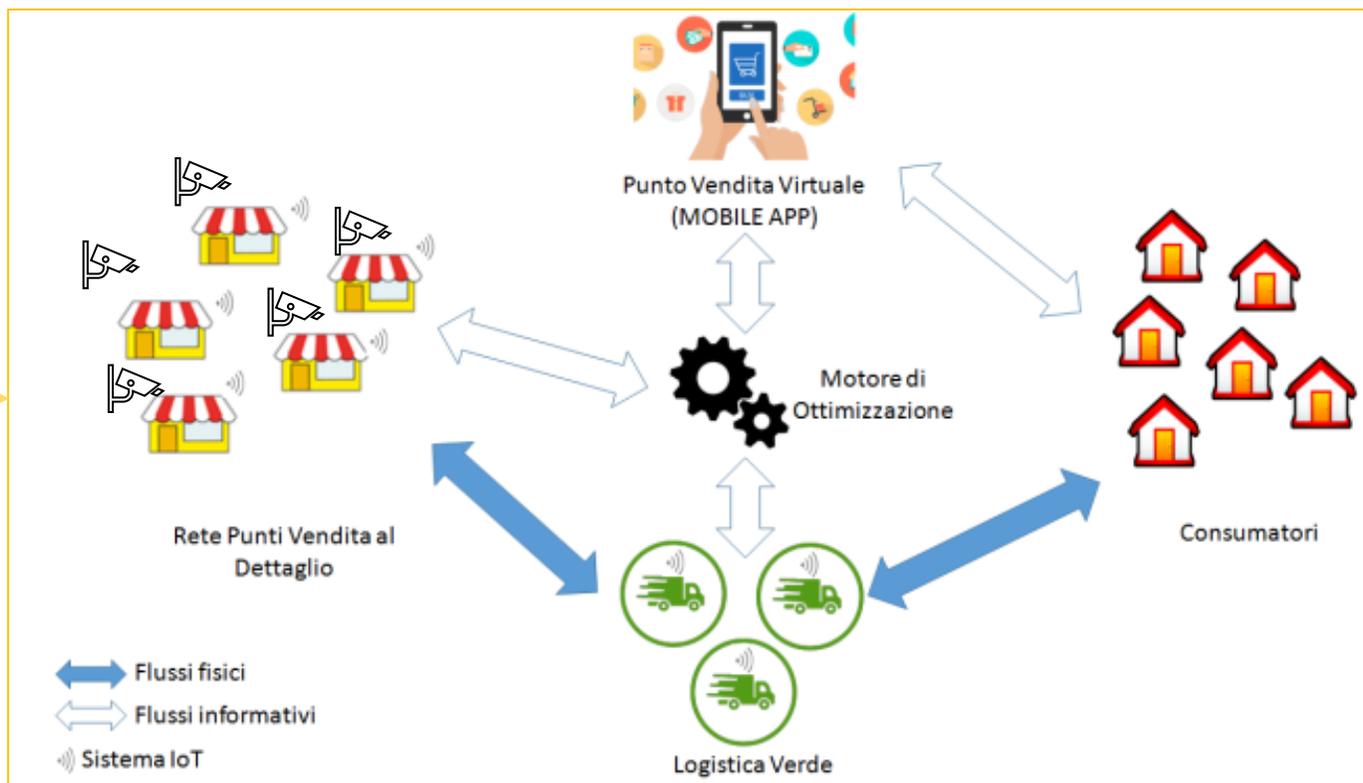
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and Interactions in Intelligent Retail Environments

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POR Puglia FESR-FSE 2014-2020
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Website: <https://www.eshelf.it/>

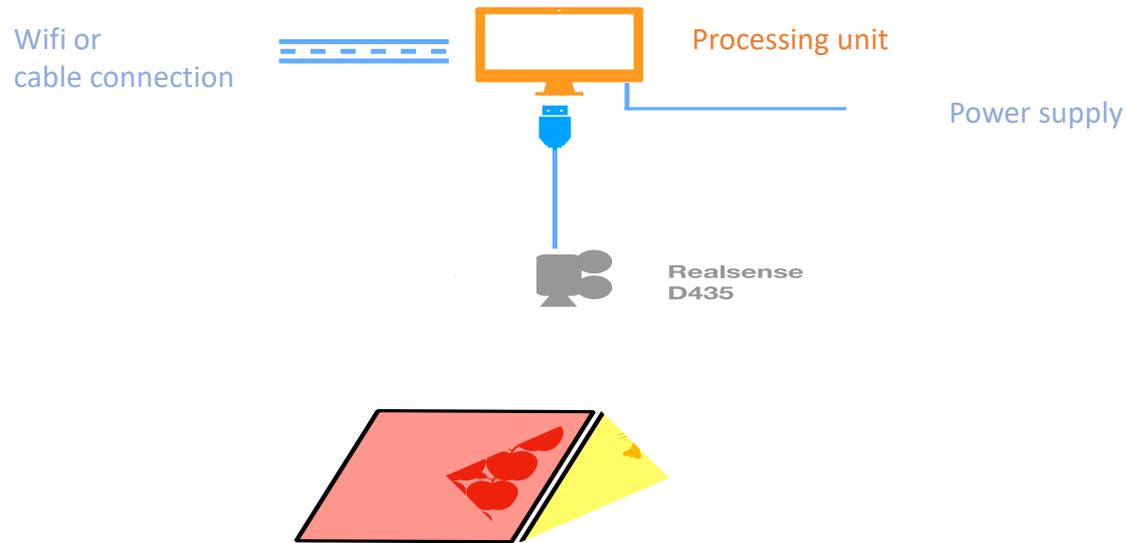


- Each point of sale will be equipped with an **artificial vision system** able to estimate shelf stocks and provide this information in real time to the virtual *market place*.
- In turn, the *market place* will expose information on stocks to the *mobile app*, which will then be able to provide updated information on product availability to the market-place users.



- A product is **Out-Of-Stock (OOS)** when it is **not available on shelf for customer purchase** for some contiguous time.
- *Efficient Consumer Response (ECR)*- Europe reports that stockouts are a **central concern for consumers**, being the third most important issue for shoppers, after the desire for shorter lines at the cash register and more promotions. If OOS conditions occur repeatedly, customer satisfaction is reduced with potentially negative effects for both retailers and manufacturers.
- **Most of responsibility for lowering OOSs rests in the retail store** with, on average, 25% of OOSs being **shelf-OOSs (SOOSs)**, i.e., the product is available but the shelf has not been refilled yet. This percentage raises at 47% when considering European countries.
- Higher checking frequency of shelves has been recognized as a useful intervention to reduce SOOSs. However, **current human-based survey practices are labor-intensive and do not provide reliable assessment, especially for Fast-Moving Consumer Goods (FMCG), fresh food and products with a due date.**

3D Vision-based Shelf Monitoring (3D-VSM)



The system is intended to continuously survey critical products, such as perishable and fresh goods stored in countertop shelves, baskets or crates.



- Based on the use of **low-cost RGB-D sensors** for early detection of Out-Of-Stock (OOS) events and estimation of On-Shelf Availability (OSA)
- Capable of:
 - ❖ Generating alerts on OOS events
 - ❖ Providing up-to-date information for stock inventory and replenishment activities
 - ❖ Updating inventory data for the e-commerce app

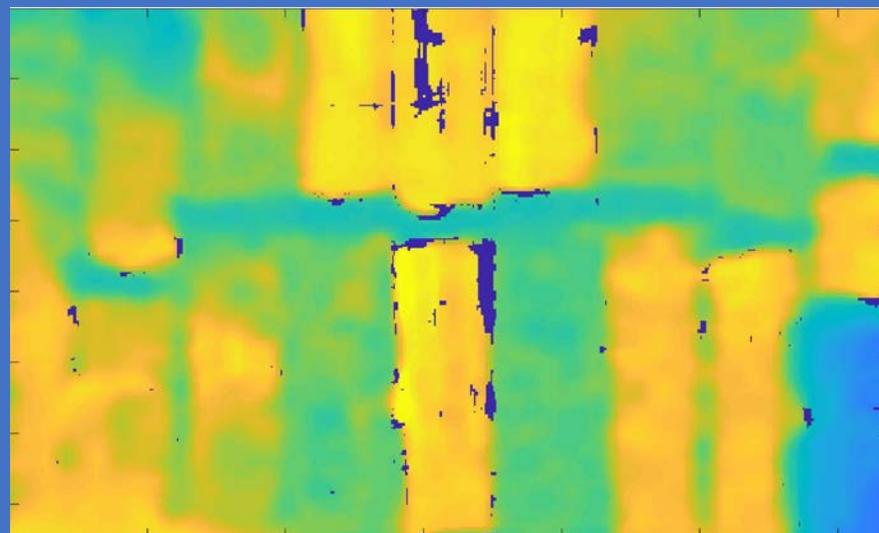


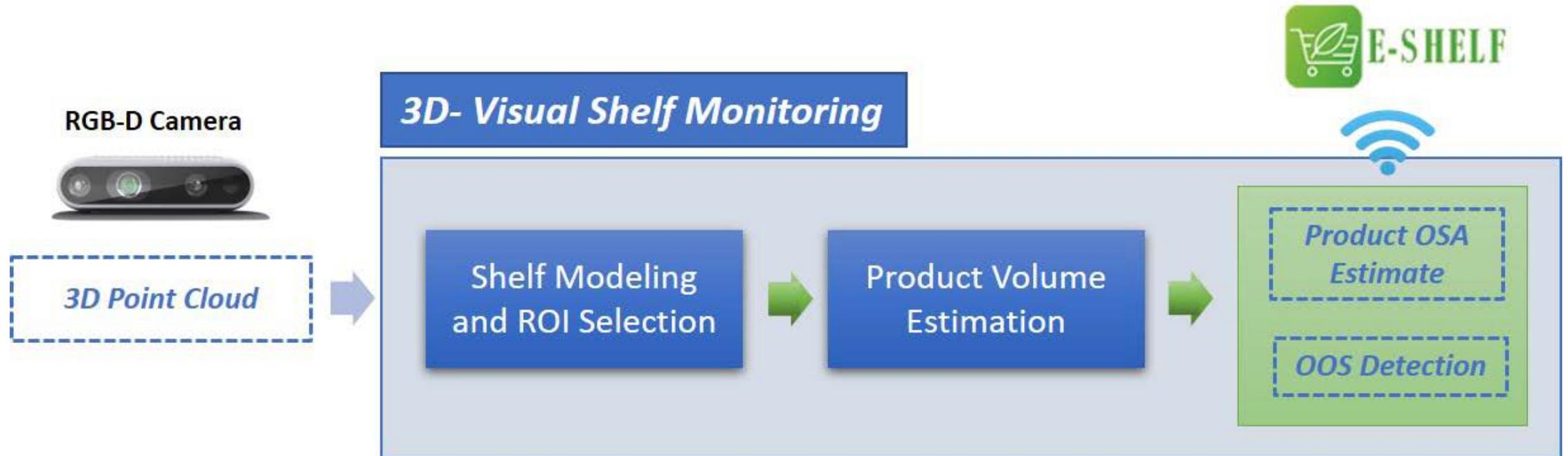
Intel RealSense D435

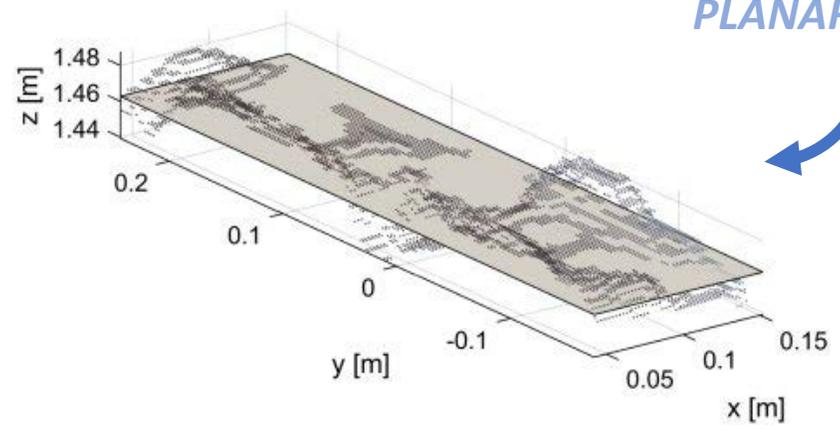
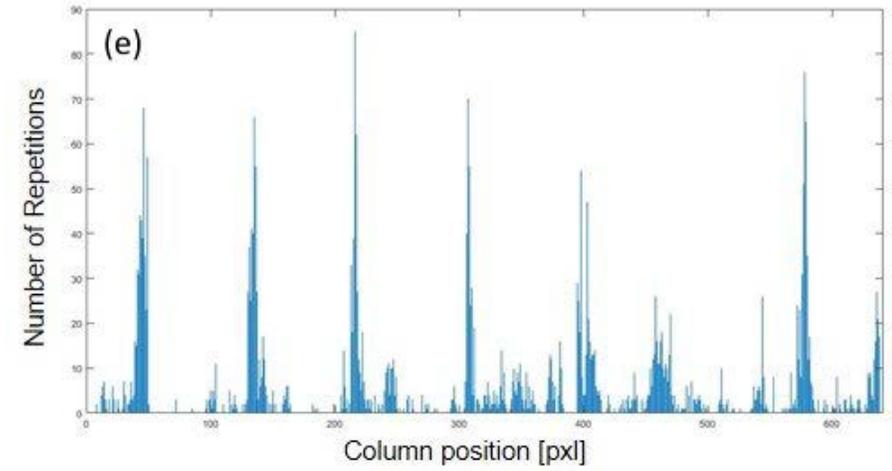
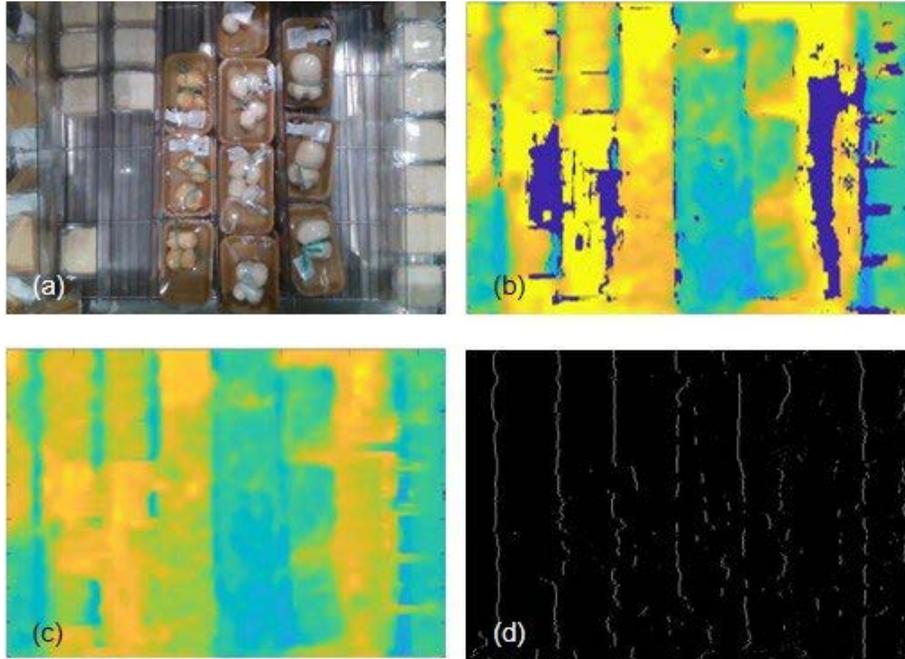
RGB IMAGE



DEPTH IMAGE





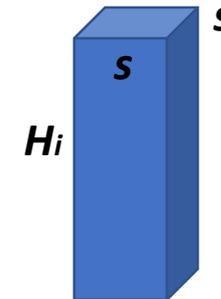
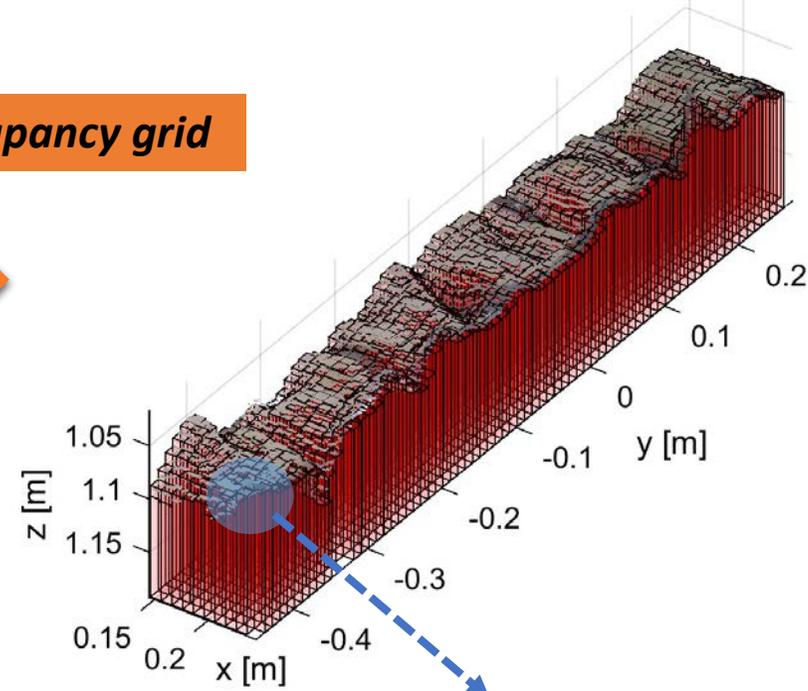


PLANAR MODEL FITTING

OSA level of a given product:
the percentage of the shelf volume occupied by product items with respect to the maximum available space



2.5 dimensional occupancy grid



(1) $V_i = s \times s \times H_i$

(2) $V_t = \sum_{i=1}^n V_i$



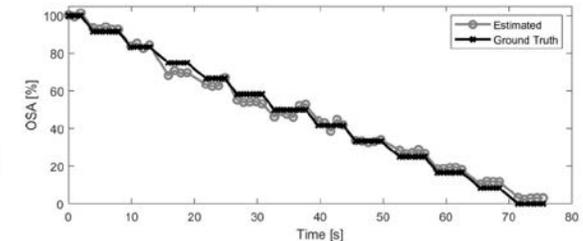
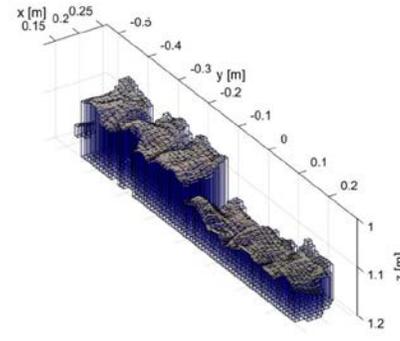
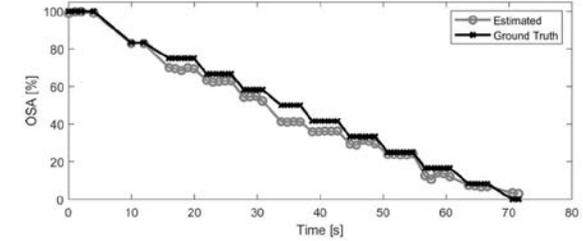
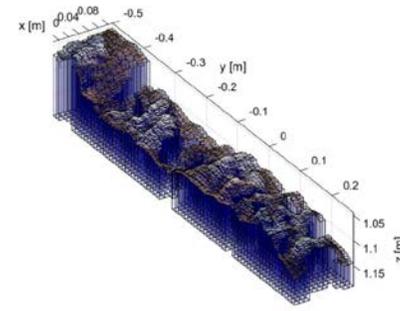
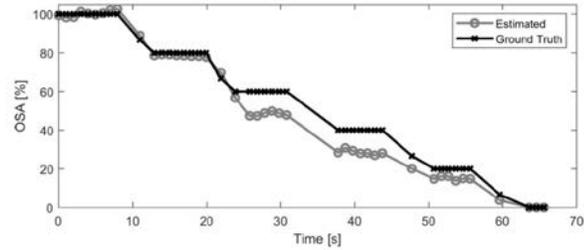
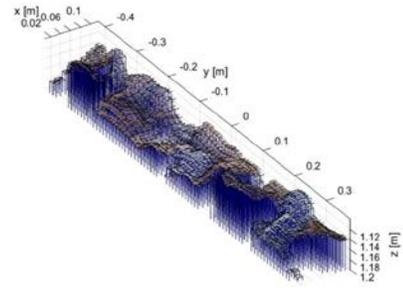
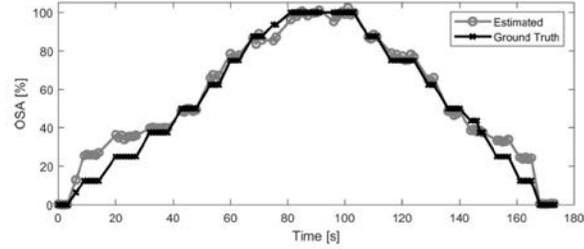
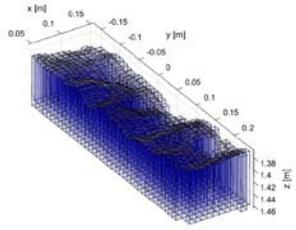
(3) $OSA_{\%} = \frac{V_t}{V_{max}} \times 100$



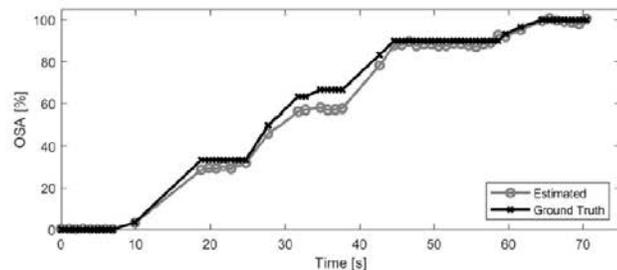
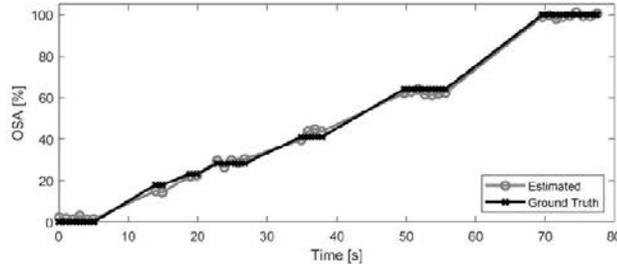
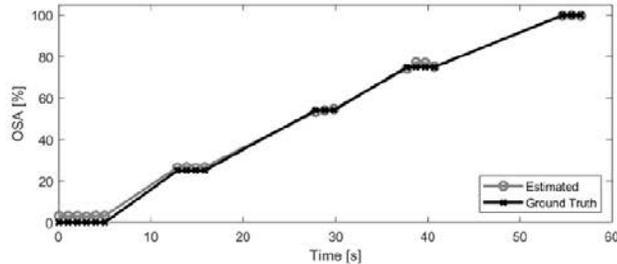
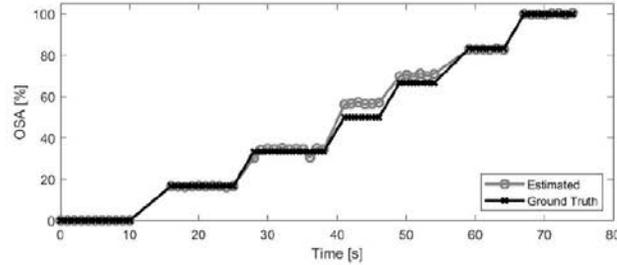
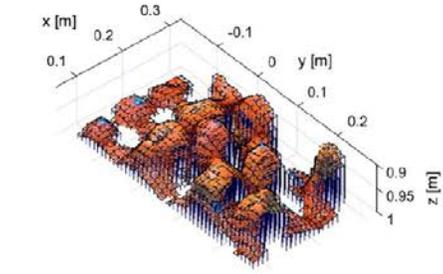
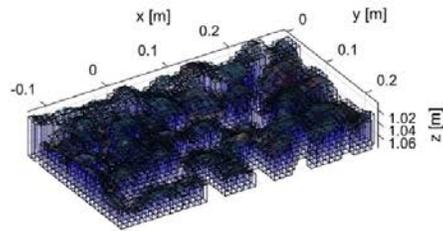
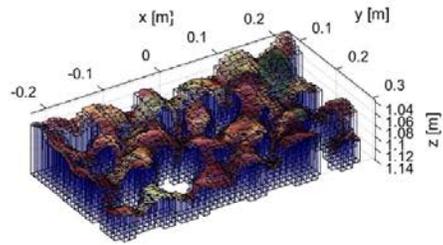
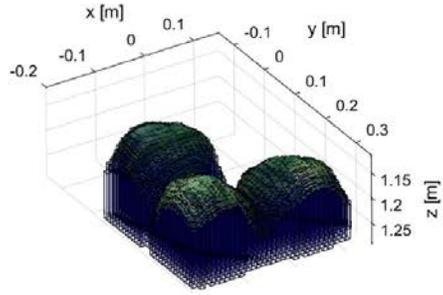
(4) $N_t = OSA_{\%} \times N_{max}$

- ❖ Each store is equipped with the 3D-VSM system for online estimation of shelf stocks, in order to reduce the misalignment between the stock data and the actual product availability in the shop.
- ❖ The integration is performed based on the TCP/IP stack protocol. Specifically, the 3D-VSM system communicates to the E-SHELF server, every 15 minutes, all the information related to the current state of the monitored shelves, including:
 - ❖ store identification number
 - ❖ shelf identification number
 - ❖ product identification number
 - ❖ product OSA





Product Type (N_{max})	\bar{E} [%]	σ [%]	r-squared
Silano (16)	3.991	4.228	0.981
Rodez (15)	5.007	4.591	0.981
Scamorza (12)	3.675	2.343	0.991
Grated Parmesan (12)	2.453	1.506	0.992



Product Type (N_{max})	\bar{E} [%]	σ [%]	r-squared
Watermelon (6)	1.514	2.141	0.995
Peach (24)	1.594	1.164	0.999
Plum (39)	1.653	0.941	0.998
Persimmon (30)	2.488	2.592	0.994

- ❖ A 3D Vision-Based Shelf Monitoring (3D-VSM) system, aimed at **estimating online the on-shelf availability of products in a retail environment**, using 3D data provided by an Intel Realsense D435.
- ❖ Experimental results obtained in a real point of sale are presented, showing that the proposed framework is **effective for online estimation of product on-shelf availability in a non-invasive and automatic way**.
- ❖ ***Future work*** will deal with:
 - ❖ development and integration of additional system functionalities, such as image segmentation and classification algorithms for automated product identification, detection of misplaced products or product occlusions and planogram compliance verification in general, also using RGB information.
 - ❖ integration on-board mobile robots or smart shopping carts, so as to reduce the need for environment infrastructuring and increase the overall system flexibility.



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Thanks for the attention!

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