First International Conference Math 2 Product (M2P 2023)
Emerging Technologies in Computational Science
for Industry, Sustainability and Innovation
May 30th - June 1st, 2023, Taormina, Italy

RECOMPOSITION OF PARTS INTO OBJECTS IN INDUSTRIAL APPLICATIONS

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ABSTRACT

When people look at the world, objects naturally emerge in their minds as a whole. If they need a more detailed understanding of an object, they focus their attention on it, draining mental resources to break the whole thing down into parts and to assign labels to each part or sub-part. In this task, they implement a typical top-down approach to experience. Machines - and the algorithms built into them - often work differently. They proceed in a bottom-up fashion by first recognizing the parts (or sub-parts such as textures) and then recomposing all the information to a higher level of knowledge, thus reaching the whole object. Like a Lego game, this recomposition requires a clear knowledge of how the whole should appear, otherwise incorrect results will be prompted. Several techniques are available to constrain the recomposition procedure to a likelihood pathway to reality. Among others, some of those which can work in real-time, learn local constraints from experience (U-net [1]), interlock sequences of sub-parts with larger locality (ViT [2]), or exploit geometrical proprieties of the embedding real space [3]. In the end, the object resulting to the final user declares its label (what I am), shape (how I am), and also confidence in those claims (metacognition). Nevertheless, errors appear, a few times on the actual label, more often on the detected shape, since it vehiculates information on the separation boundary between two or more individual objects. Each object's boundary defines where that object leaves room for another (even if it's just a background); the entire image space is labelled due to a "semantic *horror vacui*" (there is no room for knowledge holes).

In this scenario, we present a parameter-free theoretical approach to managing numerically these cases to clearly define where an object is located. The technique acts at the heatmap level of knowledge (see Figure 1), an intermediate representation where each pixel/voxel of the original data is assigned with a probability of pertaining to a specific target object. Since a heatmap could be viewed as a probabilistic field, the method is funded on statistical marginalization applied both on a label locality (single pixel/voxel - many labels) and on a spatial locality (*i.e.* many objects - many labels). By combining both localities with standard contour-finding techniques [4], the method achieves a list of objects within a 2D/3D scene with well-defined boundaries and parts not fragmented. Furthermore, different ontologies (*i.e.* the list of admissible labels) can be selected at runtime after the heatmaps have been produced. Some results borrowed from industrial applications (automated grading and sorting

of fresh fruit) are presented to demonstrate the viability of this technique in demanding industrial environments.

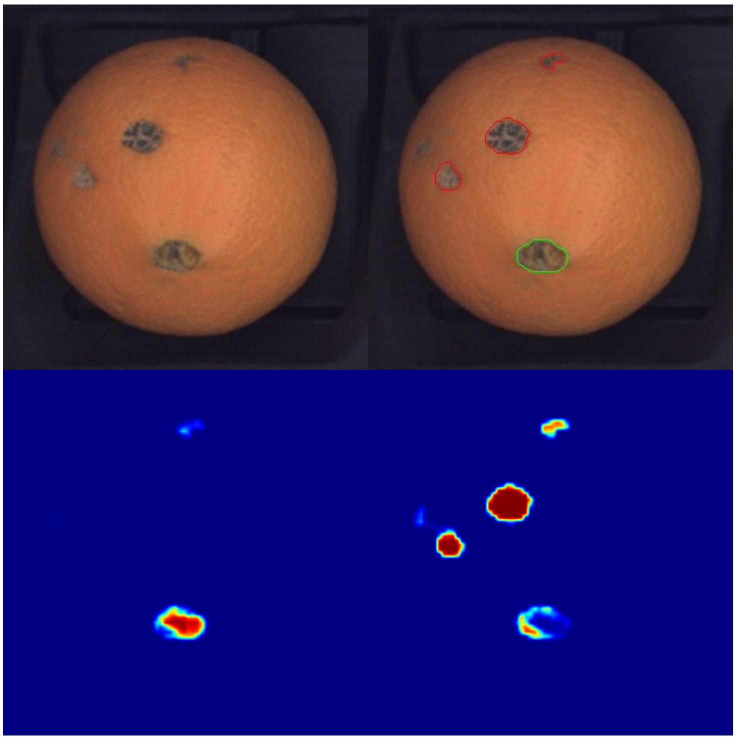

Fig 1. An orange (top-left) with resulting labels (top-right): red is hail flaw, green is calyx. Single heatmaps in jet colormap for hail flaw class (bottom-left) and for calyx (bottom-right): maximal probability is in red, minimal in blue.
(source image from Ser.mac srl, www.sermac.org).

REFERENCES

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