Technology Transfer: a Willow Perspective

Brian Gerkey

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Willow Garage

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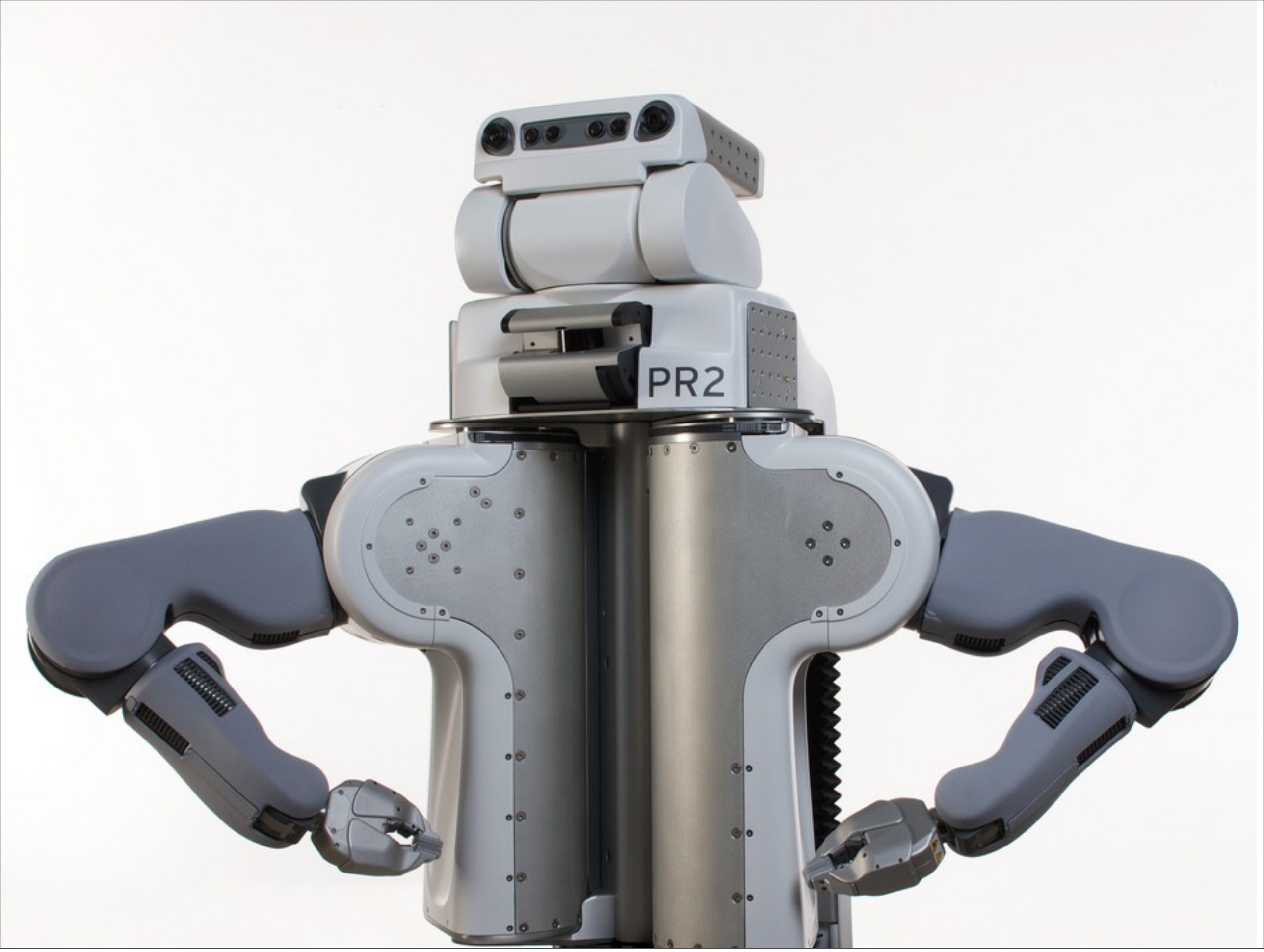
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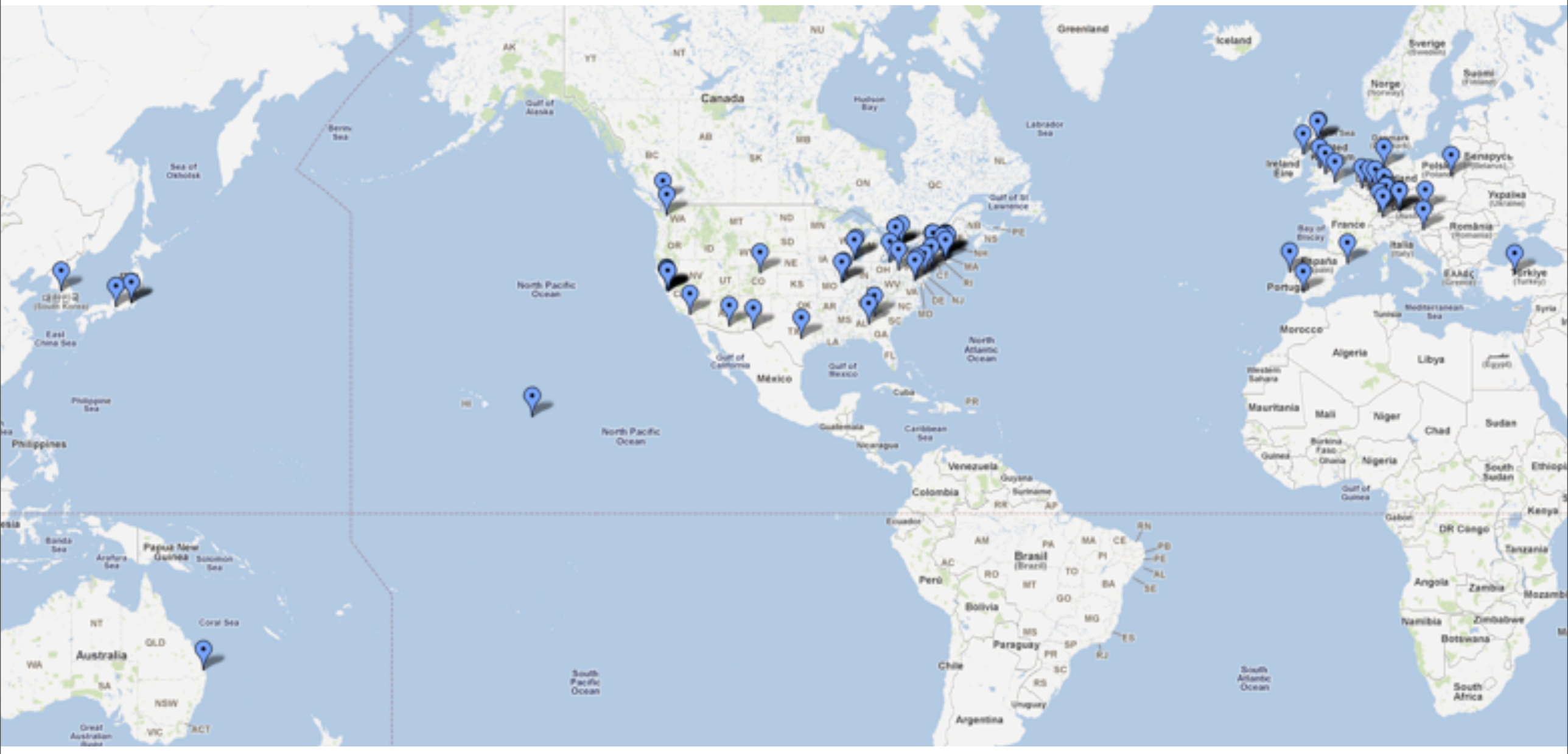

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Gradient Response Maps for Real-Time Detection of Texture-Less Objects

Stefan Hinterstoisser, Cedric Cagniart, *Student Members, IEEE,* Slobodan Ilic, Peter Sturm, Nassir Navab, Pascal Fua, *Members, IEEE,* and Vincent Lepetit

Abstract—We present a method for real-time 3D object instance detection that does not require a time consuming training stage, and can handle untextured objects. At its core, our approach is a novel image representation for template matching designed to be robust to small image transformations. This robustness is based on spread image gradient orientations and allows us to test only a small subset of all possible pixel locations when parsing the image, and to represent a 3D object with a limited set of templates. In addition, we demonstrate that if a dense depth sensor is available we can extend our approach for an even better performance taking also 3D surface normal orientations into account. We show how to take advantage of the architecture of modern computers to build an efficient but very discriminant representation of the input images that can be used to consider thousands of templates in real-time. We demonstrate in many experiments on real data that our method is much faster and more robust with respect to background clutter than current state-of-the-art methods.

Index Terms—Computer Vision, Real-Time Detection and Object Recognition, Tracking, Multi-Modality Template Matching

Real-time object instance detection and learning are two important and challenging tasks in Computer Vision. Among the application fields that drive development in this area, robotics especially has a strong need for computationally efficient approaches, as autonomous systems continuously have to adapt to a changing and unknown environment, and to learn and recognize new objects.

For such time-critical applications, real-time template matching is an attractive solution because new objects can be easily learned and matched online, in contrast to statistical-learning techniques that require many training samples and are often too computationally intensive for real-time performance [1], [2], [3], [4], [5]. The reason for this inefficiency is that those learning approaches aim at detecting unseen objects from certain object classes instead of detecting *a priori* known object instances from multiple viewpoints. The latter is tried to be achieved in classical template matching where generalization is not performed on the object class but on the viewpoint sampling. While this is considered as an easier task, it does not make the problem trivial, as the data still exhibit significant changes in viewpoint, in illumination and in occlusion between the training and the runtime sequence.

When the object is textured enough for keypoints to be found and recognized on the basis of their appearance, this difficulty has been successfully addressed by defining patch descriptors that can be computed quickly and used to characterize the object [6]. However, this kind of approach will fail on texture-less objects such as those of Fig. 1, whose appearance is often dominated by their projected contours.

Fig. 1: Our method can detect texture-less 3D objects in real-time under different poses over heavily cluttered background using gradient orientation.

To overcome this problem, we propose a novel approach based on real-time template recognition for rigid 3D object instances, where the templates can both be built and matched very quickly. We will show that this makes it very easy and virtually instantaneous to learn new incoming objects by simply adding new templates to the database while maintaining reliable real-time recognition.

However, we also wish to keep the efficiency and robustness of statistical methods, as they learn how to reject unpromising image locations very quickly and

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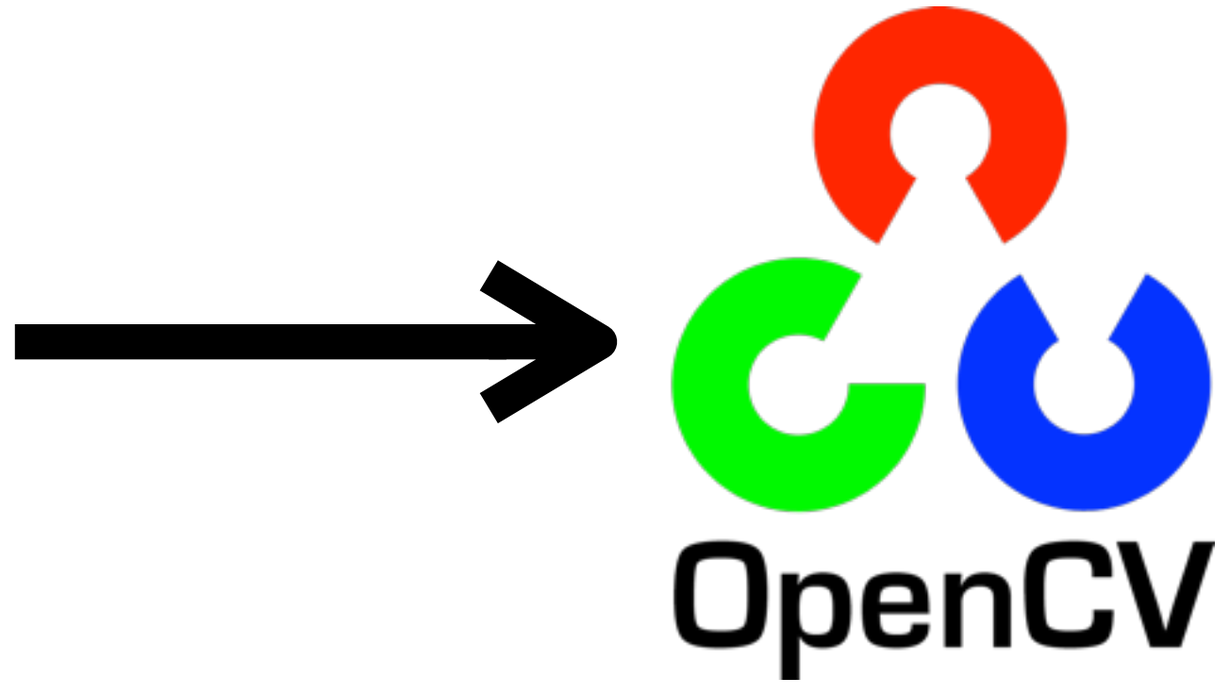


Suitable
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