



Khan, A., Aragon-Camarasa, G. and Siebert, J. P. (2017) Interactive Perception based on Gaussian Process Classification Applied to Household Object Recognition & Sorting. In: IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2017), Vancouver, British Columbia, Canada, 24-28 Sept 2017.

There may be differences between this version and the published version. You are advised to consult the publisher's version if you wish to cite from it.

<http://eprints.gla.ac.uk/146764/>

Deposited on: 28 August 2017

Enlighten – Research publications by members of the University of Glasgow_
<http://eprints.gla.ac.uk>

Interactive Perception based on Gaussian Process Classification Applied to Household Object Recognition & Sorting

Aamir Khan¹, Gerardo Aragon-Camarasa¹, J. Paul Siebert¹

We present an ongoing investigation into an interactive perception model for sorting objects observed in a workplace scene into bins based on Gaussian Process (GP) classification, which is capable of recognising objects categories from point cloud data. In our approach, FPFH features are extracted from point clouds to describe the local 3D shape of objects and a Bag-of-Words coding method is used to obtain an object-level vocabulary representation. Multi-class Gaussian Process classification is employed to provide a probability estimate of the identity of the object and serves a key role in the interactive perception cycle – modelling perception confidence. We reported in [3] results from semi-autonomous object sorting experiments in which the proposed GP based interactive sorting approach outperforms random sorting by up to 30% when applied to scenes comprising configurations of household objects. Furthermore, we briefly discuss the autonomous interactive perception approach based on GP for sorting household objects.

It is essential for service robots to have the ability to recognise objects in their immediate vicinity when working in dynamically evolving human environments. Ideally, these robots should be capable of detecting and classifying objects within their environment and then interacting with these objects without need for supervision. In [1], it is argued that physical interaction further augments perceptual processing beyond that which can be achieved by invoking deliberate changes in observation direction, since interactive perception allows the perception module to acquire potentially more information about the object(s) in the surrounding environment. Physical interaction also has the potential to reduce the complexity of the observed scene [2]. In this case interaction is encoded within a heuristic that directs the robot to grasp an object under investigation and separate it from other surrounding objects prior to investigating it further.

In this paper, we present an interactive perception system

¹Aamir Khan, Gerardo Aragon-Camarasa and J. Paul Siebert are with the School of Computing Science, University of Glasgow, G12 8QQ, UK a.khan.4@research.gla.ac.uk

that is able to sort everyday household objects into bins, each bin allocated to a specific object category, through direct visual observation (typically when objects are not occluded), and then by means of active object manipulation should objects be occluded or "difficult to recognise". Our proposed framework does not require prior knowledge about the environment or scene. We also present a visually assisted object sorting system which is capable of visually segmenting a set of household objects lying directly on the robot's workspace table and categorising those objects into their respective object classes (ie.g. juice bottles, mugs, etc.). The system has been pre-trained on a subset of these object instances, while the other subset of the objects we investigated have not been used to pre-train the system.

Our system is portable, invariant to 6 DOF object pose changes and operates close to real-time. The pipeline comprises: object segmentation, visual representation, classification, semantic visualisation and interactive perception and autonomous robotic manipulation. Our Gaussian Process classification based Interactive Perception Model (GP-IPM) has been cross-validated by comparing the categorisations results obtained when using an SVM multi-class classifier to ground truth.

The operating scenario we have adopted comprises a visual search task that attempts to locate and identify an object, such as a bottle or pen, which can potentially be partially occluded. If an initial search fails to locate an object with a prescribed minimum level of confidence, this object is then re-positioned in order to improve its potential classification confidence. Based on the above scenario, we present results obtained from experiments where the object are sorted by the probabilities of the class predictions obtained from the GP based multi-class classifier. Our current work integrates the proposed visual perception approach with autonomous manipulation skills in robot arm testbeds. A fully autonomous category-based visually-guided household object sorting is expected to be completed.

REFERENCES

- [1] J. J. Gibson, The senses considered as perceptual systems. Boston: Houghton Mifflin, 1966.
- [2] Sun, Li and Rogers, Simon and Aragon-Camarasa, Gerardo and Siebert, J Paul, Recognising the clothing categories from free-configuration using Gaussian-Process-based interactive perception, 2016 IEEE International Conference on Robotics and Automation (ICRA).
- [3] A. Khan, L. Sun, G. Aragon-Camarasa and J. P. Siebert, "Interactive perception based on Gaussian Process classification for household objects recognition and sorting," 2016 IEEE International Conference on Robotics and Biomimetics (ROBIO), Qingdao, 2016, pp. 1087-1092.

TABLE I

TABLE SHOWING TRUE POSITIVE FOR RANDOM AND GP-IPM

Scene Complexity	Method of Sorting	True Positives					Total
		Juice Bottles	Milk Cartons	Bowls	Mugs	Juice Boxes	
Uncluttered	Random	5/5	1/1	-	4/4	-	9/9
	GP-IPM	5/5	1/1	-	4/4	-	9/9
Cluttered	Random	2/4	1/2	2/3	2/3	1/2	8/14
							57%
	GP-IPM	4/4	2/2	2/3	3/3	1/2	12/14
							86%