Case Study

Robotic Grasping in Dynamic and Unstructured Environments

AUSTRALIAN CENTRE FOR ROBOTIC VISION

KINOVA
Accomplir l'extraordinaire

BACKGROUND

Seamless grasping and manipulation of known and unknown objects in unseen and changing environments – aka the real world – is arguably akin to the Holy Grail in robotics research.

While most people don't think about picking up and moving objects – something human brains have learned over time through repetition and routine – for robots, grasping and manipulation is subtle and elusive. In order to perform grasping and manipulation tasks in unstructured environments of the real world, a robot must be able to compute grasps for the almost unlimited number of objects it might encounter. In addition, a robot needs to be able to act in dynamic environments, whether that be changes in the robot's workspace, noise and errors in perception, inaccuracies in the robot's control or perturbations to the robot itself.

THE CHALLENGE

Recent advances in grasp synthesis have been made with the proliferation of vision-based deep learning techniques. However, the primary approach has been to use adapted versions of Convolutional Neural Network (CNN) architectures designed for object recognition. In most cases, this results in long computation times due to individually sampling and ranking grasp candidates.

That said, these techniques are rarely used in closed-loop grasping and rely on precise camera calibration and precise robot control to grasp successfully, even in static environments. Ultimately, the real challenge is to develop a faster and more accurate way for robots to grasp objects in cluttered and changing environments, improving usefulness in both industrial and domestic settings.

THE APPROACH

This project focused on a different approach to selecting grasp points for previously unseen objects – namely a real-time, object-independent grasp synthesis method which can be used for closed-loop grasping.

The Australian Centre for Robotic Vision (ACRV) proposed their Generative Grasping Convolutional Neural Network (GG-CNN) aimed to overcome limitations of current deep-learning grasping techniques by avoiding discrete sampling of grasp candidates and long computation times.

Rather, the approach focused on one-to-one mapping from a depth image, predicting the quality and pose of grasps at every pixel. In trials, they used a Kinova Mico 6DOF robot fitted with a Kinova KG-2 two-fingered gripper.

KEY OBJECTIVES

1

A faster and more accurate way for robots to grasp objects, including in cluttered and changing environments (as opposed to factories relying on static robotic capabilities).

2

Fast enough for closed-loop control of grasping in dynamic environments.

3

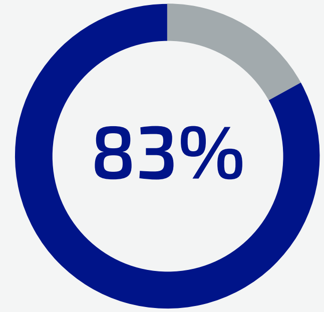
By mapping what is in front of it using a depth image in a single pass, a robot can avoid sampling many different possible grasps before making a decision, reducing computation time.

THE RESULTS

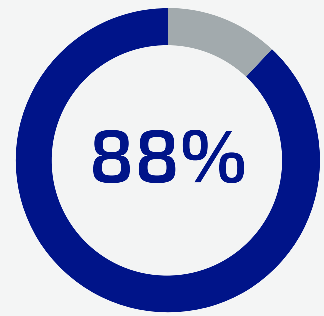
Significantly smaller and faster than other Convolutional Neural Networks, ACRV's GG-CNN is able to achieve state-of-the-art results in grasping unknown, dynamic objects, including objects in cluttered and changing environments. The final GG-CNN contained 62,420 parameters, compared to CNNs used for grasp candidate classification in other works containing hundreds of thousands or millions of parameters.

The network's lightweight and single-pass generative nature allowed for closed-loop control at up to 50Hz, enabling accurate grasping in non-static environments where objects move and in the presence of robot control inaccuracies. In rigorous trials with the Kinova Mico they performed more than 2000 grasp attempts and achieved an 83 per cent grasp success rate on a set of previously unseen objects with adversarial geometry; an 88 per cent success rate on a set of household objects moved during the grasp attempt; and 81 per cent accuracy when grasping in dynamic clutter.

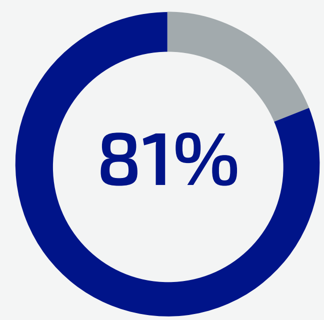
Their code is available at https://github.com/dougsm/ggcnn



Grasp success rate on a set of previously unseen objects with adversarial geometry



Success rate on a set of household objects moved during the grasp attempt



Accuracy when grasping in dynamic clutter

> **The Kinova Mico offers a fantastic research platform. Why? Quite simply because it is robust and easy to use (not forgetting its awesome software), making it the ideal platform to prototype from. The new Gen 3 looks like it has super-sized in terms of hardware, packing an even more powerful punch as a research tool.**

Doug Morrison, *PhD* Researcher, Australian Centre for Robotic Vision

Kinova is a global leader in innovation robotics. Founded in 2006 in Boisbriand, Quebec, Canada, Kinova's mission was initially to empower individuals with upper-body limitations through assistive robotics. Over a decade later, the company has evolved its solutions and product suite to service new markets — helping researchers, medical professionals, governments, businesses and educational institutions achieve their innovation goals through strategic partnerships and collaborative efforts.

Today, with an ever-evolving line of robotic technologies built up over more than a decade of inspired ingenuity, and a dedicated team spanning all corners of the world, our company's collective mission is — and always will be — to empower humanity to go well beyond its limitations and achieve the extraordinary.

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The Australian Centre for Robotic Vision is an ARC Centre of Excellence, funded for $25.6 million over seven years to form the largest collaborative group of its kind generating internationally impactful science and new technologies that will transform important Australian industries and provide solutions to some of the hard challenges facing Australia and the globe.

The Centre has assembled an interdisciplinary research team from four leading Australian research universities: QUT, The University of Adelaide (UoA), The Australian National University (ANU), and Monash University as well as CSIRO's Data61 and overseas universities and research organisations including INRIA Rennes Bretagne, Georgia Institute of Technology, Imperial College London, the Swiss Federal Institute of Technology Zurich, University of Toronto, and the University of Oxford.