Mohammed VI Polytechnic University (UM6P)
International Artificial Intelligence Center of Morocco (Ai movement)

Grasp Synthesis for Hand-Object Interactions

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1   Research Motivation

The advanced dexterity capabilities of the human hands allow us to safely and robustly manipulate objects of various shapes, sizes, and materials. Building machines inspired by human hands, with the functionality to autonomously pick up and manipulate objects has many applications in AR/VR, robotics and human-machine interaction. However, this task is very challenging and necessitates a deep understanding of human grasping and manipulation techniques.

This thesis comes in the context of a project launched by OCP Group and Ai Movement that aims to use a dual arm robot for a non-destructive manipulation of industrial parts and systems. In this project, a dual arm robot capable of manipulating tools dexterously, robustly, and safely is needed. While predicting robot grasps with parallel jaw grippers have been well studied and widely applied in robot manipulation tasks, dexterous manipulation with multi-fingered hands has the potential to equip robots with human-like dexterity and enable them to generalize across diverse environments, goals, and tools. However, the study of natural human grasp generation with a multi-finger hand remains a very challenging problem [1].
In this context, we propose a thesis that will contribute to solve the problem of generating human-hand object interaction. Our aim is to investigate new solutions to the problem of predicting human-hand grasp of 3D objects in order to allow effective and non-destructive manipulation of industrial parts and systems.

2   Problem Statement

The problem of robot grasp prediction with jaw grippers have been widely addressed and studied in robotics. However, the study of grasp generation using human-like hand is more challenging [2]. While grasping is natural for humans, it involves complex hand configurations and soft tissue deformation that can result in complicated regions of contact between the hand and the object. In addition, the hand is characterized by a complicated structure with a high degree of freedom that makes the pose more difficult to understand, analyze and reproduce.
Recently, understanding and reconstructing hand-object interaction receives growing attention from

the computer vision and computer graphics communities [3, 4, 5, 6]. In this thesis we aim to investigate this problem to come up with new models and approaches to understand and synthesize the human hand pose. More Specifically, we aim to address the following questions; (1) Given a 3D point cloud of and object, how we can generate a plausible hand pose that can grasp and handle the object correctly? This includes the need to understand the object's shape and environment and the challenge of generalization to new unseen objects. (2) How to generate physically plausible 3D human hand motion to move the object into a target location and pose ? This involves generating continuous interaction with objects to move them while maintaining a stable grasp throughout the interaction.

3 Research Scope

The aim of this thesis is to explore new deep learning based approaches to model and generate realistic human-hand object interactions. Firstly, a state-of-the-art review should be performed in order to understand the achieved advance, the existing challenges and the promising directions that can be investigated. Next, we aim to propose new deep generative models that synthesize the human-hand pose and motion to correctly interact, manipulate and grasp a given 3D object. Our goal is to publish these contributions in high impact computer vision conferences (*e,g.*, ICCV, CVPR, ECCV) and journals.

4 Admission Criteria

The PhD position is proposed by the International Center of Artificial Intelligence of Morocco, of the Mohammed VI Polytechnic University. Applicants with excellent cursus must be holders of a Master's, an engineering or an equivalent recognized degree in Computer Science or Applied Mathematics. In addition, they should have skills in Programming (Python and C++) and good communication skills in English. Particular attention will be given to the suitability of this research project with the applicant's background.

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