Good afternoon, everyone. Today I am so honored to be here and present our project which is called optimal grasp for modularized and retractable vaccum gripper system. First of all lets go through a brief overview about the content of todays presentation. I divide the presentation into five main section including motivation, challenge, our proposed framework, the progress report and finally with a conculsion section. `(start)`

Without further ado, lets take a closer loot at the motivation of our project. As you could see, there are mainly three categories of gripper to perform the pick-and-place action by utilizing the automation capability of robotic arm.Those grippers are parallel jaw gripper, soft gripper, and vacuum gripper block. For the left figure, it is the example of parrallel jaw gripper and they are caplbe of peroforming antipodal grasp, frienly to selective pick out the specific object from a clustered environment. But it is limited for the size of the object. For the soft gripper, it could provide passive compliance from the material characteristics. And it has high adaptability to variety of manipulated object. However it has a complex model when cotacting with the object. And the last one which is label with red edge, it is the most common one that is picked for indsutry application of production line. And it is quite easy to employ for picking up the objects with high weight. But it also has the limitation that the object should have regular and flat surface. So there is a niche for the industry that remains unresolved. For that vaccum gripper block we mentioned previously, those gripper still could not used for the transmission line to deliver the objects with uneven mass distribution and irregular surface such as large packed ice food shown in the left two pictures. To further narrow down the gap, several criterions for gripper need to be met by some novel design. The gripper need to perform the quick and stable grasp during automated transmission line, and it should provide the active adapive capability to complex object geometry. Last but not least, the gripper structure should be universal for different application scene. `(motivation)`

Following with that need, our collaborator HKFLAIR proposed the novel design of modular and retractable gripper which each of individual gripper has two unique fuctionality that includes a freedom of degree for the variable displacement along z-axis. And it could perform the suction force at the end tip of suction cup. With that design, we could use the gripper to form different block system in different scenarios. And for our case, we are using the system with 4x4 individual gripper array to grip any irregular object. The schematic diagram shows the adpatability of this gripper system for arbitrary shape objects. In the same time, this gripper actually has a challenge for us to control since they has a quite large dimensions for the variables that we could control. Also it requires a high accuracy of the visual system to analyze the 3D geometry of object to further determine the 6D pose. Then we introduces a model free reinforcement learning approach to tackle the problem. `(bottleneck)`

Before going to the AI driven decision system, I would like to briefly introduce the low-level controller of our robotic system. With the configuration of the robot, the kinematics tree could be built and construct a relationship between joints lvel space and cartesion end effector. Then we could pass the reference pose determined by our AI system that will be introduced in later section and interpolate it to fedd into the differential inverse kinematic solver to get the desired joint velocites. Finally it will passed by a PID controller to convert the command to a current or voltage to drive the motor at each joint. Please notice that there are some feedback loops from the robot sensor to our control loops. `(low level controller)`

Now, we propose a model free reinforcement learning framework to decide the next target grasp pose. We define our grasp task as a MDP which is valid assumption because the next future state will not be affected with the entire history of system state. To descirebe a markov decision process, there is a four tuples including action, observation, reward and trainsition model. Since we are using DDPG algorithm which is model free, so the transition model is omitted. The action space contains the 6D grasp pose, displacement of retraction and activation status for each individual gripper. The observe status include the vision information and also the propriocetion information given by the robotic arm. The DDPG framework includes actor and critic network for diffent purpose, the actor is actually the policy that maps the observation state to the next action and the critic takes the action from the actor and the current observation to give the critic comment that evaluate the current actor policy. The right bottom structure shows the actor network. As you could see there is a CNN structure to extract the feature from the vision system. The CNN networks is inspired by Alexnet that the size of convolution kernel is decresing to extract the feature in a coarse-to-fine manner. And other information will be processed with MLP or fully-connected layer. Finally it will output the action command. And this slide shows the structure of critic network that is inside the blue dashed block. It also includes CNN, MLP as a encoder to output the Q value which determines the goodness of current policy. Next, I will show some simulation result for our robotic system and manipulation environment. `(model free rl + critic)`

The first video illustrates the retraction fuctionality of each gripper and the other video shows the planning procedure of the grasp. At that time, the suction could not be properly performed in the physical simulator, but I latter fixed the problem. and you could see from this video. However, there is a strange behaviour from the existing package of vacuum gripper in ROS-Gazebo. As you could see the object is spinning and fall off during moving of the robot. For now, we built the simulation with some problem and latter fixed the problem and train the agent with our porposed framework firstly in simulation.`(demonstration + progress)`

Now I will conclude our presentation with this slide. the goal and deliverables of our projects comprises the physical simulation of the robotic system that mimic our indusrty application scene. And develop an AI-driven approach to plan the optimal grasp stratehy for the novel design of the gripper system. Lastly, we would like to transfer the knowledge learned in simulation to the reality with hardware set-up. There are also some works awaiting to be finished which including the problem in current physical simulators and trian the agent with different kind of the object thta has irregular surface shape. Then the domain randomization need to be performed during training to increase the level of generalization. If we found a difficulty to transfer the policy in simulation to reality, we planned to use another LSTM controller to predict the dynamic difference between the simulator and the real work. The commad from policy in simulation could be easily mapped to the policy used in reality. `(conclusion)`

That's all about my presentation of our project, thanks very much for your attention and listening. `(Thanks)`