

	UR5 + Modular Grasper + Kinect	UR10 + Dexterous Hand Plus + Kinect	Dexterous Hand Plus + Phase Space
Price of every component from quantity 1	Modular Grasper: £20k UR5 for academia: £21.4k Kinect: £250 Others: COTS	Dexterous Hand: £95k UR10 for academia: £26.95k Kinect: £250 Others: COTS	Dexterous Hand: £95k Others: COTS
Where available (e.g. US, EU, China, etc.)	Globally	Globally	Globally
Hardware configuration			
How many parts in total		3	2
Power requirements (Average / Maximum) in Watts	Max 450W	Max 450W	Max 500W
Cable connections for any external devices			
Sensors			
In robot arm	Joint position	Joint position	Joint position
In robot gripper	Joint position, joint velocity (from position sensor data), joint torque, motor temperature	Joint position, joint velocity (from position sensor data), tendon force, motor temperature	Joint position, tendon force, motor temperature
In camera	Point cloud, depth image, RGB image	Point cloud, depth image, RGB image	Point cloud, depth image, RGB image
Additional sensors	Tactile sensor options	Tactile sensor options	Absolute localisation of fingertips and in-hand objects
Low-level interface (means explicit command of values at every interface cycle)			
API language(s) (e.g. C++, Python, Java)	C++, Python (ROS)	C++, Python (ROS)	C++, Python (ROS)
Interface frequency (read and write) in Hz	Modular Grasper: 1kHz UR-5: 125Hz	Hand Plus: 1kHz UR-10: 125Hz	Hand Plus: 1kHz Phase Space 960Hz
Command level (e.g. Position/Velocity/Torque, Joint space / Cartesian space)	Modular Grasper: Joint torque @1kHz from host (@ 10kHz internal loop on uC), Joint position @ 1kHz UR-5: Joint position/velocity @ 125Hz Moveit integration provides cartesian path planning and execution for end effector.	Hand Plus: Joint position @ 1kHz, Tendon Force @1kHz from host (@5kHz internal loop on uC) UR-10: Joint position/velocity @ 125Hz Moveit integration provides cartesian path planning and execution for end effector.	Hand Plus: Joint position @ 1kHz, Tendon Force @1kHz from host (@5kHz internal loop on uC)
Robot state: What data is available via the interface, e.g. q and dq?	Arm: Joint position, Joint velocity	Arm: Joint position, Joint velocity	Joint position, tendon torque, external object localisation, fingertip localisation
Model: Is the robot model (i.e. M, C, G, J) available at interface frequency?	Fixed URDF model is used. It is not updated during execution.	Fixed URDF model is used. It is not updated during execution.	Fixed URDF model is used. It is not updated during execution.
Gripper commands: What commands can the gripper receive (e.g. position, velocities, forces)	Joint position, joint torque, grasp control Also trajectory control via ros_control	Joint position, tendon torque Also trajectory control via ros_control	Joint position, tendon torque Also trajectory control via ros_control
Gripper state: What data is available via the interface, e.g. width	Modular Grasper: Joint position, Joint velocity, joint torque	Hand Plus: Joint position, Joint velocity, tendon torque	Hand Plus: Joint position, tendon torque
Gripper access: Can the gripper be accessed at interface frequency (read and write)?	Yes at 1kHz	Yes at 1kHz	Yes at 1kHz
Hardware: How can the interface be connected to external computers?	Ethernet ports (Modular Grasper uses etherCAT and can be plugged to a standard PC ethernet port)	Ethernet ports (Hand Plus Grasper uses etherCAT and can be plugged to a standard PC ethernet port)	Ethernet ports (Hand Plus Grasper uses etherCAT and can be plugged to a standard PC ethernet port)
Protocol: What protocol does the interface use?	EtherCAT (Modular Grasper), TCP/IP (UR5)	EtherCAT (Hand Plus), TCP/IP (UR10)	EtherCAT (Hand Plus), TCP/IP (Phasespace)
Minimum requirements of external PC to run the interface (CPU, RAM, network card, etc.)	2 available network ports, USB 3.0	2 available network ports, USB 3.0	2 available network ports