INTRODUCTION

The Tactile Telerobot is the world’s first haptic telerobotic system that transmits realistic touch feedback to an operator located anywhere in the world. It is the product of joint collaboration between Shadow Robot Company, HaptX Inc, and SynTouch Inc.

This document gives an overview of how products from Shadow, HaptX, and SynTouch interface with each other, and details the technical specifications of each product.

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TACTILE TELEROBOT: SYSTEM CAPABILITIES

OVERVIEW

The Tactile Telerobot integrates three products, each the leader in its respective category. HaptX Gloves bring industrial-grade haptic feedback and natural interaction for precise and intuitive input control. The Shadow Dexterous Hand mimics human hand dexterity, replicating the movements and position of the human operator’s hand. SynTouch BioTac sensors capture tactile information and transmit haptic feedback data back to the operator’s hand with high accuracy and low latency. When all three of these products come together, the whole is greater than the sum of its parts. The Tactile Telerobot is a first-of-its-kind system and is now available for advanced research and development in teleoperation.

KEY BENEFITS

- **Natural interaction**
  Robot operators intuitively control robotic hands, with little to no training required.

- **Realistic haptic feedback**
  Tactile and force feedback give the operator critical control information, improving speed and reducing errors.

- **High dexterity**
  Capture of full range of hand motion

- **Precise control**
  Sub-millimeter motion capture accuracy

- **Remote operation**
  Control robot from anywhere in the world

An operator wears HaptX Gloves on his hands. Two Shadow Dexterous Hands and two UR10 arms mimic the operator’s movements. SynTouch BioTac sensors mounted on each of the robot’s fingertips sense the surface and edges of the Rubik’s Cube. Haptic information is transmitted back to the operator, who feels the sense of touch through the gloves.
SHADOW DEXTEROUS HAND

OVERVIEW

The Shadow Dexterous Hand is an advanced humanoid robot hand system that provides 24 movements to reproduce as closely as possible the kinematics and dexterity of the human hand. It has been designed to provide comparable force output and movement precision to the human hand.

Shadow Hand systems have been used for research in grasping, manipulation, neural control, brain computer interface, industrial quality control, and hazardous material handling.

The Shadow Dexterous Hand is a self-contained system - all actuation and sensing is built into the hand and forearm. All versions of the Hand use an EtherCAT bus (Ethernet for Control Automation Technology), providing a 100Mbps Ethernet-based communications field-bus, and full integration into ROS (Robot Operating System).

KIT CONTENTS

- Control systems
- Software (provided under GNU GPL or BSD)
- ROS compliant
- PC
- Power supplies
- Tactile Sensing
- Auxiliary equipment (as needed)
- Documentation and training

FEATURES

- Anthropomorphic: Human Hand Size and Kinematics
- 20 Actuated Degrees of Freedom and 4 Under actuated Degrees of Freedom
- Position sensing at each joint (24)
- Motor current and temperature at each actuator (20)
- Strain gauges at each tendon (40)
- 1kHz Bandwidth
- EtherCat interface
- ROS Integration

SPECS

- Weight: 4.3 kg
- Payload: 5kg
- Speed: ~ 1s full range of motion at each joint
- Size: Similar to typical male hand
- Communications: EtherCat 100Mbps
- Joint Angle Sensing: 1kHz, 12b, 0.2 degree resolution
- Tendon Force Sensing: 5kHz, 12b, 30mN resolution
- Motor Temp/Current/Voltage: 100Hz
HAPTX GLOVES DEVELOPMENT KIT

OVERVIEW

HaptX Gloves bring industrial-grade haptic feedback to digital interactions. They’re the only product that delivers the combination of realistic touch feedback and natural interaction required for professional virtual reality applications, robotic teleoperation, and telepresence.

HaptX Gloves have been used by the world’s leading automakers, systems integrators, and Fortune 500 companies for immersive design, training, and research in virtual reality.

The HaptX Gloves Development Kit includes one pair of HaptX Gloves, supporting equipment, and a fully featured SDK, enabling users to create immersive haptic experiences with natural use of their hands.

HaptX Gloves
Natural interface with realistic touch
• 130 points of tactile feedback per glove
• Up to 18 Newtons of force per digit
• Sub-millimeter motion capture precision

Air Controller
Precision air regulation and control for gloves
• Size: 46 x 41 x 15.5 cm
• Connected to each glove via 1.25 meter tether
• Silent operation

Motion tracking system
• Magnetic data acquisition hardware
• Size: 16.5 x 29 x 50 cm (two stacked boxes)

Smart Compressor
Supplies clean air to console
• Size: 18 x 20 x 30.5 cm
• Low volume, suitable for office environment
HAPTX GLOVES DEVELOPMENT KIT

**KIT CONTENTS**
- HaptX Gloves
- HaptX Air Controller
- HaptX Smart Compressor
- Motion Tracking System
- SDK
- Documentations and training

**FEATURES**
- High displacement tactile feedback on fingers and palm
- Independent pressure control for each tactile actuator
- Independent force feedback per digit
- Individual digit position and rotation tracking
- Unity and Unreal Engine 4 plugins
- C++ API for custom integrations

**GLOVES SPECS**
- Weight: 0.45kg
- Size: one size fits most
- Tactile actuators: 130 per glove
- Independent tactile channels: 66 per glove
- Max tactile displacement: ~1.2mm
- Tactile control resolution: 12-bit per actuator

**AIR CONTROLLER SPECS**
- Weight: 18kg
- Size: 46 x 41 x 15.5 cm

**SMART COMPRESSOR SPECS**
- Weight: 16kg
- Size: 20 x 38 x 38 cm

**MOTION TRACKING SPECS**
- Weight: 4kg
- Size: 8 x 14.5 x 25
- Update frequency: 240 Hz
- Accuracy: <1 mm
- Latency: 8 ms
- Tracked DOFs: 30

**SYSTEM REQUIREMENTS**

**Electrical Requirements**
100–240 V, 50–60 Hz, 1100 W max

**Functional Requirements**
The gloves achieve precision motion tracking by generating a magnetic field. Large metal objects, including some desks and chairs, can distort this field and reduce the quality of the motion tracking. Users are encouraged to keep the Gloves at least 45 cm from sources of distortion.

**Air Supply**
The HaptX Gloves are pneumatic-powered and require a constant supply of 3 bar air for operation. A compressor comes standard with the kit. Customers must contact HaptX if they prefer to supply alternate air source.

**Storage**
The kit should be set up in a climate-controlled office environment. Please contact HaptX if use in other environments is required.

**Warning**
Air Controller contains high voltage electronics. Do not disassemble or expose to liquids. Smart Compressor contains pressurized air up to 3 bar. Do not exceed supply air pressure rating. Always follow instructions in the user manual. Improper use could result in serious injury or death.
SYNTOUCH BIOTAC SP

OVERVIEW

The SynTouch BioTac mimics the physical properties and sensory capabilities of the human fingertip. The design consists of a rigid core surrounded by an elastic liquid filled-skin to give a compliance remarkably similar to the human fingertip.

The BioTac is capable of sensing: force, vibration, and temperature which is identical to human touch capabilities. These sensory capabilities have been incorporated into the device without placing a single sensor in the skin. Instead, all of the electronics are protected inside the rigid core.

KIT CONTENTS

- BioTac sensors
- Documentation
- Cheetah SPI-USB interface (for testing)
- Multi-BioTac Board and Cables (for testing)
- Software (for testing)

FEATURES

- Contains all the sensory capabilities of the human fingertip
- Can determine point of contact, normal, and shear forces
- Sensitive to dynamic contact and vibrations
- Detects temperature and heat-flow
- Similar to the human fingertip in size, shape, and compliance
- Robust design that protects electronics
- Easily replaceable skins
- Software for collecting and processing data
- Can be installed on virtually any robotic platform

SPECS

- Weight: <10g
- Max Load: 100N

<table>
<thead>
<tr>
<th>SENSOR MODALITY</th>
<th>RANGE</th>
<th>RESOLUTION</th>
<th>FREQ. RESPONSE</th>
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<tbody>
<tr>
<td>Force</td>
<td>0-50N</td>
<td>10 mN</td>
<td>0-100 Hz</td>
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<tr>
<td>Fluid Pressure</td>
<td>0-100 kPa</td>
<td>37 Pa</td>
<td>0-1040 Hz</td>
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<tr>
<td>Microvibration</td>
<td>±760 Pa</td>
<td>0.4 Pa</td>
<td>10-1040 Hz</td>
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<tr>
<td>Temperature</td>
<td>0-75 C</td>
<td>0.1 C</td>
<td>0-22.6 Hz</td>
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<td>Thermal Flux</td>
<td>±1 C/s</td>
<td>0.001 C/s</td>
<td>0.45-22.6 Hz</td>
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</table>
UNIVERSAL ROBOTS UR10

OVERVIEW

The UR10 is a 6-axis robot arm with a working radius of 130 cm. The UR10 is Universal Robots’ largest collaborative industrial robot arm, designed for tasks where precision and reliability are of paramount importance. The UR10 allows for tasks with payloads that weigh up to 10 kg.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Weight</td>
<td>28.9 kg</td>
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<tr>
<td>Payload</td>
<td>10 kg</td>
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<tr>
<td>Reach</td>
<td>130 cm</td>
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<tr>
<td>Joint ranges</td>
<td>360 degrees</td>
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<tr>
<td>Repeatability</td>
<td>+/- 0.1 mm / +/- 0.0039 in (4 mils)</td>
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<tr>
<td>Footprint</td>
<td>19 cm</td>
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<tr>
<td>Degrees of Freedom</td>
<td>6 rotating joints</td>
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<td>Control box size</td>
<td>475 x 423 x 268 mm</td>
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<td>Communication</td>
<td>TCP/IP 100 Mbit: IEEE 802.3u, 100BASE-TX Ethernet socket &amp; Modbus TCP</td>
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<tr>
<td>Noise</td>
<td>Comparatively noiseless</td>
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<td>IP classification</td>
<td>IP54</td>
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<tr>
<td>Power consumption</td>
<td>~ 350 watts using a typical program</td>
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<td>Operating temperature</td>
<td>0-50°C</td>
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<tr>
<td>Power supply</td>
<td>100-240 VAC, 50-60 Hz</td>
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</table>
TACTILE TELEROBOT

Package Options

Tactile Telerobot systems are available with two hardware options: unimanual (one hand) and bimanual (two hands), and two service options: an Integrated Package (standard support) and an Application Development Package (premium support).

Tactile Telerobot systems are available for purchase or lease. Pricing and shipping information is available on request.

**Integrated Package: Unimanual**

- Includes one Shadow Dexterous Robot Hand (right), one HaptX Gloves Development Kit, five SynTouch BioTac SP sensors, and one Universal Robots UR10 arm.
- System ships with installation and expert training, includes limited applications engineering service.

**Integrated Package: Bimanual**

- Includes two Shadow Dexterous Robot Hands, one HaptX Gloves Development Kit, ten SynTouch BioTac SP sensors, and two Universal Robots UR10 arms.
- System ships with installation and expert training, includes limited applications engineering service.

**Application Development Package: Unimanual**

- Includes one Shadow Dexterous Robot Hand (right), one HaptX Gloves Development Kit, five SynTouch BioTac SP sensors, and one Universal Robots UR10 arm.
- System will be delivered to customer with installation and training included. Customer will receive engineering support for specific hardware and software applications.

**Application Development Package: Bimanual**

- Includes two Shadow Dexterous Robot Hands, one HaptX Gloves Development Kit, ten SynTouch BioTac SP sensors, and two Universal Robots UR10 arms.
- System will be delivered to customer with installation and training included.
- Customer will receive hardware development for specific applications.

Contact

Email info@tactiletelerobot.com and a representative will get in touch with you shortly.