ROBOTIC TELEPRESENCE
State of the Industry 2013

Telepresence robotics, remote presence, virtual presence - these terms describe technologies that allow a remote operator to control a robotic platform from afar and interact with remote participants using video.

In the past few years, the telepresence robotics market has exploded with a number of new offerings that range from simple solutions allowing participants to remotely pan and tilt video-enabled tablets or camera-equipped arms to an increasing number of full-sized devices complete with remote navigation capabilities, multiple cameras for navigation and conversation, multiple Wi-Fi radios for uninterrupted connectivity and various other advanced features.

Many companies and individuals love the concept and get the value of robotic telepresence. With traditional videoconferencing, the remote person's viewpoint is limited to wherever the camera happens to be located in the room (wall mount, cabinet top, etc.) and the local participants find themselves interacting with a large screen that may or may not be collocated with the camera. In robotic telepresence, the remote person is able to engage with local participants as if they are physically located at the point of the device. Since the point-of-view of both parties converge on the same device, a better engagement results. And since the device can move around, the remote people are able to move themselves to better locations or situations, creating a much better engagement with other locals outside the teleconference space. In the simplest terms, the fact that you can look or even move around the room increases the feeling of "being there."

The technology includes a number of other non-intuitive benefits, such as allowing for random co-worker interactions that lead to serendipitous brainstorming instead of scheduled videoconferences that limit the dialogue to the meeting agenda. People tend to accept remote workers so readily as "present" that they can identify coworkers by the way they pilot the device around the office, even if you can't see their face on the screen.

MARKET BURDENS AND TECHNOLOGY HURDLES

The robot market has proven to be trickier than expected. Despite the obvious benefits and appeal, a few pockets of market resistance must be overcome before we can see significant adoption. These pockets of resistance include both market perception issues and actual design challenges.

It takes a leap of faith to be an early adopter of new technology. Market perception issues are expected with many new technologies, and despite our familiarity with Hollywood robots, it's still unusual to see one in the workplace. Despite the incredibly positive feedback from existing device owners, we are still primarily in that early adopter phase.

Also, Hollywood has created extremely unfair expectations, resulting in possible disappointment when viewing the actual options. As cool as they are, today's telepresence systems still don't compare to C3P0 or the mechanisms from Surrogates. It's extremely difficult to design a visually appealing and fully functional device while keeping its costs within an acceptable range for a small business collaboration tool.

The Double Robot uses an iPad as the display and video codec.

The Revolve Robotics Kubi holds a video-enabled tablet or smartphone that can be controlled by a remote participant for a more fluid and natural video call.

We also have actual technical and design challenges to overcome. The most obvious example is the elevator problem. How can you navigate your device from one floor to the next if it loses Wi-Fi and disconnects from the remote user in the elevator? Another challenge is the fact that driving the device eventually stops being fun and becomes a bit of a chore. While driving it around a classroom to get a good view of the teacher isn't a problem, guiding it through multiple hallways while dodging people and obstacles is another story. Eventually, self-navigating systems should make this a non-issue.

Other adoption blockers include potential network requirements. With any new video enabled deployment, the potential for increased, bandwidth-intensive video traffic must be provisioned for and network security must be maintained. Additionally, a different type of security concern must be addressed for a device with electronic eyes and ears that can roam the building. The market will have to work hard to assure consumers that these devices can be deployed securely with proper authentication and controls.

On a positive note, we expect robotic telepresence to get some boost from the fact that videoconferencing, in general, is finally achieving the massive growth we have long anticipated. At its core, robotic telepresence is simply another use case for videoconferencing. As VC becomes more and more ubiquitous, the benefits of VC applications such as robotic telepresence should become more understandable and marketable.

TELEPRESENCE ROBOTICS: ELEMENTS AND FEATURES

Those interested in implementing robotic telepresence as a part of their collaboration environment should carefully consider which feature sets match your priorities, and choose a vendor accordingly. While no two devices in this field are the same, all share several common elements.

Presence: There are two aspects of presence to address here. First, it's important to provide a quality camera so that the remote user can truly see and engage with the local participants. It's equally important to represent the remote user with as much fidelity as possible. This requirement drives a need for a display that faithfully represents the user's visage to remote participants. In fact, some people may be uncomfortable with the idea of a monitor-less robot, considering it to be quite intrusive and spy-like. The monitor immediately identifies the remote user and fosters a true face-to-face experience. Monitor sizes and configurations vary greatly, so choose based on your needs and preferences.

Height: Like people, robots come in all shapes and sizes. Some are suited for a sit down, across-the-table meeting, others are approximately standing height, while some have variable heights that may be adjustable locally or by the remote user. Again, your needs may vary.

Navigation: Navigating a device can be tricky. While most systems come with a fairly intuitive app for remote users, the real issue is the remote user's point-of-view. Without

Robotic Telepresence

5 Ft.

4 Ft.

3 Ft.

2 Ft.

1 Ft.

| QB Avatar | Beam Robot | Double |

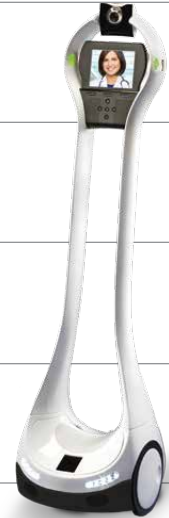| COMPANY NAME	Anybots	Suitable Tech	Double Robotics	Gostai	MantaroBot	MantaroBot	VGo
ROBOT NAME	QB Avatar	Beam Robot	Double	Jazz Connect	TeleMe	Classic	VGO
BASIC INFORMATION							
Availability Date	Now	Now	Now	Now	Now	Now	Now
Price and Per-Month Charges (if any)	$9,700 $79 to $269/mo	$16,000	$2,499 ($1,999 pre-order). No monthly charge.	Starting at 8900€. No monthly charge.	$1,650 No monthly charges	$3,700 No monthly charges	$5995 plus $100/month (includes 5 services)
Height	34 to 74 inches	5' 2"	Adjustable: 47" - 59"	1meter / 40 inches	5'	5'	48" or 60"
Weight	35 lbs	92 lbs	15 lbs	9Kg / 19 lb	16 lbs	45 lbs	19 lbs
Footprint	0.3 m2	25" x 18"	10" x 9"	41cm X 35cm	16" by 12"	16" by 16"	13" wide x 15" deep
Top Speed	5 feet / sec	3.3 mph	Slow-moderate walking speed	Limited to 1m/s	1.4	1.5	Over 2.5 fps
Battery Life	6 to 8 hours	8 hours of use	8-10 hours per charge	4 hours	8 hours with standard battery; extended battery available	4 hours with standard battery, extended battery available	Over 12 hrs with extended battery, 6 hrs with standard battery
Docking Station	Yes	"Hands-free" Dock with unique ID	No	Yes (automatic reconnection)	Yes	Yes	Included. VGo auto docks itself.
AUDIO PERFORMANCE							
Microphone(s) Type; Quality and Specs	3 microphones	6 MWM uni-directional mics (1 facing rear)	iPad's microphone	Long range high quality sound	Uses Tablet's microphone (iPad or Android)	Digital USB Microphone	4 Omni directional mics. 8Khz HD audio.

Tale of the Tape: 2013

|	Jazz Connect	TeleMe		Classic		VGO
Speaker(s) Type; Quality and Specs	1 speaker	Misco 15 Watt	iPad's speakers	Powerfull loudspeakers for very noisy environments. Headphone accessory for more confidentiality	Uses Tablet's speakers	Two 1.2W speakers	HD Tweeter / Woofer Combo speakers in base and head
On-Bot Video Display				yes			
Display Size	3.7"	17" (4:3)	Full-sized iPad 2 or later	5'	Depends on user's choice of tablet (e.g. 10.1" Display in iPad or Samsung Galaxy Tab 2 10.1)	16" wide-screen monitor	6"
Display Resolution / FPS	320x280, up to 30 fps	1280x1024, 60FPS	iPad's resolution / FPS	Up to VGA/20fps	Depends on user's choice of tablet	1366 by 768 pixels Up to 720P/30FPS	VGA up to 30 fps
PILOT VIEW/CONTROLS							
Display Resolution / FPS	640x480, up to 30 fps	Unlimited	iPad or iPhone's resolution / FPS. Can also be controlled from a web browser	Up to 720p / 25 fps (standard VGA at 20 fps)	Uses Tablet display and camera	Uses main camera / 720P – 30 FPS	VGA up to 30 fps
Turn head/camera independently from body	No, turns on center	No	No	Yes with automatic body alignment	Yes tilt/pan Tablet independent of base	Yes	No by design. Easier operation, higher reliability, friendlier interaction
Second camera for navigation	Yes, 1 down camera	Yes	Yes	Yes	No	No	No – not required. Has Auto-tilting driving mode.

Navigation assistance (auto pilot / obstacle avoidance)	Yes	In progress	No	Obstacle detection, automatic camera orientation	Infrared sensors for obstacle detection with feedback integrated with control application	Infrared sensors for obstacle detection with feedback integrated with control application	Stair prevention. Obstacle avoidance assistance. No auto pilot except docking.
Navigation integrated with video display, or a separate app.	Navigation integrated	Yes	Integrated	Integrated and fully web-based (no software to instal)	Separate Controller App for PC or Mac allows use of any video application that is compatible with the selected Tablet	Separate Controller App for PC or Mac	Integrated.
NETWORK REQUIREMENTS							
Networks Supported; Number of Radios	802.11 b/g/n	2 802.11abgn radios Verizon & ATT 4G	Wifi or 4G / LTE	Wifi a,b,g,n with roaming	Wifi or Cellular, 1 Radio	Wifi or Cellular, 1 Radio	Up to 3 radios Verizon 4G LTE 1 or 2 WiFi: each supporting 2.4 and 5.0 Ghz and complete support for advanced 802.1X security protocols
Bandwidth Required (min and recommended)	0.5 mb symmetric minimum, 1 mb recommended	250Kbps min, recommend 1 Mbps up, 2 Mbps down	1 Mbps	25KB/s for LD, 200KB/s for HD	500kbps/1.5Mbps	500kbps/1.5Mbps	Min 200kbps, 1 Mbps recommended
Video protocols supported (interop abilities)	Proprietary video protocols	Proprietary	WebRTC. iOS SDK will be available	Fully web based. Interoperability not applicable	Any A/V application supported by user's choice of tablet (Skype, Google Hangout, Polycom, Vidyo, WebEx, Gotomeeting etc.)	Skype, Microsoft Lynx, others coming	H.264 codec, XMPP communications
Unique Features:	· Laser Pointer · Robust 2 wheel self balancing, safe in crowded environments · High wheel clearance · Can attach instruments, with network & power served by QB · Drive via browser	Custom 2 radio Wifi connectivity, predictive path visualization, audio array with echo and noise cancellation, powerful speaker for noisy environment, capable of climbing ADA ramps, pilot screen sharing, LED headlights, 2 HD cameras with super wide angle, capable of moving small objects like chairs, doors out of the way	· Self-balancing robot will remain upright even if bumped into by people or things · Very light. Carry by hand & transport in your car · Safe. 15 lbs can't cause much damage to property or hurt pets · Downward facing camera built-in · Camera height adjustable remotely · Control from web browser from any OS · Easy software upgrades: 1 normal app from Apple's App Store · Easy hardware upgrades: Replace iPad with latest one from Apple · 3rd-party hardware add-ons supported · 3rd-party software integration supported (via software API) · Regular wifi - no extra setup needed · Free compatibility test app available before purchase	Fully web-based (no software to instal), double camera for navigation (170deg wide angle) and specific tasks (5MP screenshot with short range autofocus). Orientable head for fast point of view change and a better interaction.	· Optional Laser pointer aimed with Pan/Tilt control of Tablet; · Compatible with most networks including 802.1X networks that require security certificate; Available API for user customization	· Optional Laser pointer aimed with Pan/ Tilt control of camera; · Motorized telescoping mast adjusts height; play videos remotely, available security guard app; · Available API for user customization	· Aesthetically pleasing design (voted "Coolest Product") · "Click and Drag" Simple Driving w/ infinitely variable speed and direction · Auto-transferred snapshots · User controlled camera and "raise hand" lights · 5X no loss Zoom · Text to Speech · Audio Muting · Audio & Video Muting · Network downloadable images · Head lights · Status lights · 2MP HD Camera · AES & TLS Encryption · Firewall port tester · "Presence" indicators · VGoNet Manager web administration of VGos and users · Scheduled user access · 100% remote controlled · Can pivot in its own tiny footprint

the ability to look down and see the robot's base, it's often difficult to avoid bumping into things, though some systems do include obstacle detection sensors. Other devices allow the remote user to point the main camera downward while navigating, while others include a second, lower, camera for navigation. Finally, at least one device (the Double Robot) has been programmed to follow people around when gently pulled, much as an obedient dog when led by a leash.
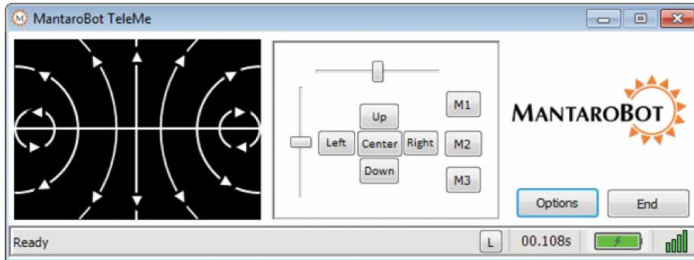
The user interface for the MantaroBot offers point and click navigation

Videoconferencing: A number of these devices use Skype or other free consumer VC apps, while others use proprietary video software. Be sure the device you choose can provide the video quality you need, and ideally some integration with your existing communications environment.

Other Consideration: Please review our "Tale of The Tape 2013" Robotic Telepresence chart (in this issue) for pricing, as well as additional features and comparison points.

New Product Subcategory: "Neck and Head" Robots

There's a reason that standard videoconferencing room systems generally offer Pan / Tilt / Zoom cameras with far end control. The ability for the remote user to turn the device's head and look around naturally during a meeting is often seen as the strongest feature of a telepresence robot.

A new product category tries to have the best of both worlds, tablet/phone stands that allow users to look around during a meeting and are small enough to be carried from location to location, eliminating the need for remote navigation. From vendors like Revolve Robotics and Swivl, these solutions provide remote pan / tilt functionality to a mobile device hosting a video call.

New Product Subcategory: Video Enabled Remote Arms

IBM recently announced a camera equipped robotic arm called MRO for Mobile Maintenance, Repair and Operations. The device is designed to be carried by a field service technician to a factory floor, set up next to the malfunctioning widget, and controlled remotely by a more senior technician or product expert. The field technician can use both hands and the remote expert can be working with multiple techs in multiple locations simultaneously.

CONCLUSION

Telepresence Robotics has always been a "when, not if" technology. Unfortunately, until recently the answer has been "not yet." However, advances in remotely controllable devices continue to progress alongside advances in videoconferencing technology, both benefiting the Telepresence Robotics field.
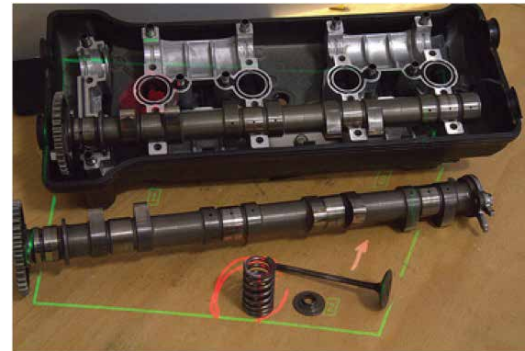
IBM's MRO examining an engine block. The remote supervising expert can use a laser designator to call out specific parts to the field tech.

While some technophiles were onboard from day one, the rest of the world is coming along slowly. As the telepresence platforms continue to improve and potential customers get past their preconceptions, the value case should become clearer to all. At some point in the near future, working in multiple global locations via remotely pilotable surrogates may become a regular part of the day. **TPO**

ABOUT THE AUTHORS

Sanford Dickert is a consultant with the **Human Productivity Lab**, a catalyzing technologist, product expeditor and a remitting/relapsing roboticist. Involved in the intersection of engineering, collaboration, and design, Sanford has been at the forefront of a number of breaking social and robotic technologies. Most relevant was being the VP of IP Product and Services for Interoute Telecommunications and Product Director for the Texai Remote Presence system, one of the first commercial remote presence systems (seen on *The Big Bang Theory* as the 'Shel-bot'). Sanford is a prolific writer and his enthusiasm for remote presence systems can be found at Pilot Presence (www.pilotpresence.com).

David Maldow, Esq., is a visual collaboration technologist and analyst with the **Human Productivity Lab** and an associate editor at *Telepresence Options*. David has extensive expertise in testing, evaluating, and explaining telepresence and other visual collaboration / rich media solutions. David is focused on providing third-party independent analysis and opinion of these technologies and helping end users better secure their visual collaboration environments. You can follow David on Twitter and Google+.
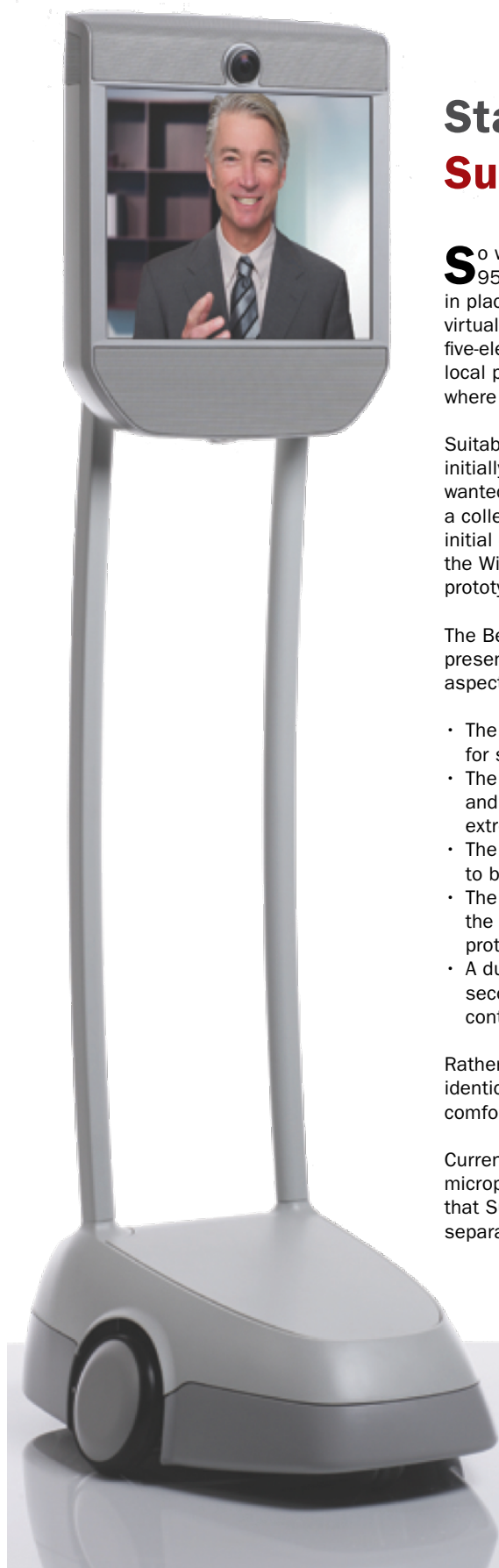
State of the Art:
Suitable Technologies Beam

So what is the state of the art in robotic telepresence? Meet Beam. A $16,000, 62-inch, 95-pound remotely pilotable telepresence robot that serves as your digital surrogate in places far, far, away. Boasting the largest display of its class, the Beam displays your virtual visage at 1080P resolution, 60 frames per second at a life-size proportion. It has a five-element microphone array with an adaptive algorithm that ensures proper pickup of the local person's voice even in a crowded conference environment. It also shows on screen where you intend to go.

Suitable Technologies is a spinoff of the famed robotics laboratory Willow Garage, which initially developed the device as a prototype for an electrical engineer in Indiana who wanted a better solution than Skype on a laptop. The original version, called Texai, was a collection of off-the-shelf components designed to test product/market fit. After some initial customer feedback, including the famed Shel-bot episode from The Big Bang Theory, the Willow Garage team decided to back off the market opportunity with a cobbled-together prototype and focus on the issues the Texai highlighted.

The Beam is the result of two-plus years of research into how to enable a pilot to establish presence in another location without detracting from the pilot's conversation. Presence aspects include:

· The 17" screen seated about 5"6' off the ground - which is approximately normal height for standing face-to-face interactions.
· The head contains a state-of-the-art microphone array which performs noise canceling and excellent sound localization for the pilot wherever the head is pointing - even in an extremely noisy environment like a CES conference hall
· The base is low and heavy to the ground such that it is almost impossible for the device to be knocked over, unless intentionally forced.
· The video between pilot and locals is so fast; the latency so small that it feels like the pilot is behind a window talking directly with the locals - using a proprietary video protocol (assumed to be based off of Google's WebM protocol)
· A dual wifi radio solution allows for one radio to be connected to a network while a second radio is seeking all other networks to determine the optimal network to use for a continual seamless experience.

Rather than light-weight plastic, the Beam is made with carbon-fiber reinforced plastic identical to the plastic that Lenovo uses to build its Thinkpads, giving the Beam a comfortable solidity without the unnecessary weight of metal.

Currently the Beam is controlled by an operator using a PC, high-end webcam and microphone solution running Suitable's proprietary navigation application. Rumor has it that Suitable is building a full-on pilot station, leveraging the RPD technologies to provide a separate physical interface rather than leveraging a pilot's laptop and webcam.