

# Telepresence Robots for Remote Workers

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*At present, about 15,000 remote workers in the World are at workplace virtually, using telepresence robots. In the paper we describe some application scenarios of such robots and technical details.*

The idea of telepresence appeared tens or may be thousands years ago, but commercial implementing it gained only after wide spreading of internet, not expensive computers and manufacturing technologies.

By now there are developed more than 30 modifications of such robots, almost all of it is presented at telepresencerobots.com website, but really in demand and actively sold (by telepresencerobots.com, amazon.com, eBay.com and alibaba.com) only four of them: Double, Beam, PadBot and BotEyes.

It is very difficult to get used to the idea of telepresence, like to all unusual and not widespread in the community. The main part of consumers regard such robots like toy. However, worldwide, it has already sold about 15 thousand such robots, that really help companies in resolving of below mentioned issues and provide a huge economic impact with payback in a few months. In fig. 1 you can see the telepresence robots market grow.

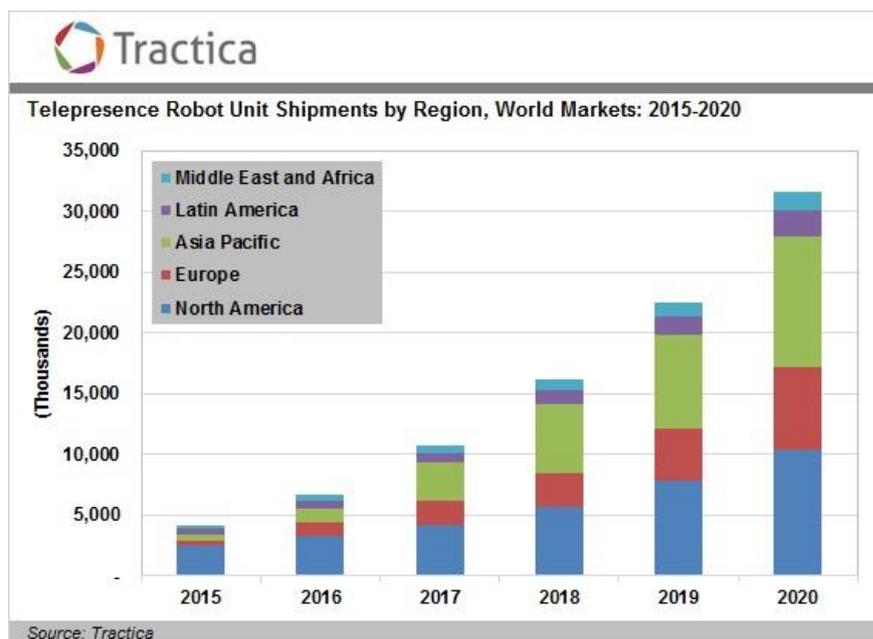


Fig. 1. From website <https://www.tractica.com>

## Application scenarios

Remote operation using telepresence is the main application of this type of robots. Two scenarios are most demanded by the market:

- a) the employee, being at home or on a business trip, participates in the life of the company and works exactly as if he was in the office, among his colleagues;
- b) the head of the company, which has several offices, performs its functions by communicating with the staff or other managers remotely, with the help of a robot.



### Application of robots by remote workers

Remote work can be reasonable used in the following cases:

- when it is impossible to find in your city an employee with the necessary specialization, with unique abilities or a certified expert. For example, you found it in China, Russia or Santa Clara, but your company is located in San Diego;
- when the employee himself / herself cannot go to the office every day or it takes a very long time due to family circumstances or due to illness;
- when the employee is forced to be on a business trip for a long time, but his presence in the office is also necessary;
- when an employee must be in several places within one day. For example, the lecturer should give several lectures in different cities within one day; the head of the personnel department should interview candidates for work in several employment offices; the general customer wants to visit several co-executors in one day;
- when it is necessary to "appear" at the customer urgently to understand the reasons of failure of the equipment installed by you or to adjust it by hands of the personnel of the customer;
- when the personally presence economically impractical: only one or two trips can cost thousand dollars and exceeds the cost of the robot.

*Here are more specific case studies*

Suppose you are a programmer of a CNC machine, working at home. Before milling the part, usually first they track the trajectory of the cutter visually, "by air", before putting the workpiece on the machine. If you work at home, with the help of a robot you can remotely view the trajectory of the cutter before installing the parts and then during the milling process, even if the machine is located in China, and you

are in San Jose. The telepresence robot wheels allow you to drive up to the machine and consider the process from the desired angle. Similarly, you can see how the installer soldered your PCB, how the part was cut out on a CNC laser machine, what tooling and fixtures the assembler uses in the manufacture of the product according to your project.

#### *Another case*

You ordered the injection mold in other city, put it in an molding machine, which is located in China and cast detail. The item turned out to be defective. If you have a telepresence robot, the mold developer can remotely determine the nature of the defect, look at the instrument panel of molding machine, remotely perform (with your help) selection of more appropriate modes or make changes to the size and location of the tunnels by redesigning the mold.

#### *Third case*

Suppose you are a home worker programmer in a team working on a shared project. Every day there are meetings you must attend, the team members gives the ideas that require discussion during work day. If your telepresence robot is turned on constantly and the image from its camera is displayed through the HDMI interface on your home TV, then you have a full feeling that you are sitting in the same room with the rest of the programmers, hear replicas concerning everyone and can drive "on the robot" to anyone and discuss the subtleties in the project. Your face is always visible on the robot monitor. During the meeting you see not only the one who speaks, but also the expression of the face of the rest of the audience, their facial expressions, hear their statements. Further, in such events they usually use a board on which paint chalk schemes, diagrams, charts, etc. The robot allows you to turn to the board, drive closer, if you need to consider something in close distance. The effect of full presence is created, which is not reproduced by fixed monitors of traditional video conference.

### **Application of robots by managers**

The managers need telepresence robot in the following cases:

- if the company has several offices in different cities or countries. There are communication tasks of the company head with heads of remote offices (tasks of a teleconference);
- if the company head lives in another city;
- if the company owner or manager want to check what employees do in the remote office, how often they smoke and whether they are going to «groups for informal communication»;
- if company head can remotely show the company to remote customer;
- if the manager wants to see how the contractors fulfill the order performing, for example, in China;
- if the buyer wants to inspect a large machine, room or process, your manufacturing process;
- if the company builds a new office or workshop, the director can monitor the construction process at any time instead of spending time on travel.

### **Other applications:**

- remote participation in scientific, economic or political forums;
- remote visit to the exhibition;
- if the office is in one place and the warehouse is in another, then the robot can control how the goods are stored in the warehouse, how the storekeeper releases it, whether they politely communicate with visitors.

## **The essence of telepresence and alternatives**

The essence of telepresence is very clearly described in the movie "Avatar". It is a complete remote presence, with all the sensations and emotions associated with it, with the transmission of signals from and to all the sense organs. The robot, which provides only tele-controlled video and audio communication, physically transmits only sound and video, but psychologically achieved a much stronger effect – the robot allows you to see facial expressions, gestures, eye expression, changes in the situation, the movement of people in the room and feel the movement of himself. It's much more than just a video conference. This creates a feeling of your presence in the team. Psychologically it is quite another level of communication than phone or video conference.

The following alternatives are available for implementing remote presence:

- robots that do not have wheels, but allow you to change the direction of the screen and webcam;
- teleconference systems when large fixed video screens are installed in the room, which display the image of remote persons;
- small-sized robots - toys with telepresence function;
- PTZ video cameras (their rotation in two planes can be controlled via the Internet);
- normal computer with Skype installed.

The common difference between these variants and telepresence robots is the inability to move the point of presence in the space or the inconvenience of communication (as in the case of toys).

## **Technical details**

Consider the features of commercially available telepresence robots (Fig. 2).



Fig.2. The most wide spread telepresence robots

The robot Double 2 has only two wheels. This made it lightweight and stable in the longitudinal direction due to the electronic stabilization system, but the fee for this is the lack of stability in the transverse direction. The robot has a small distance between the wheels, so it falls as soon as it is hooked sideways for an obstacle or one wheel drive on the hill. In fact, he can only move the wire on the floor. Therefore, although it allows you to adjust the height and at its maximum is the highest robot presented in the table, it should be keep in mind that the increase in height reduces the already poor stability. Fortunately, the tablet holder allow the tablet not to break when the robot falls down.

Other robots do not use the segway principle and their stability is determined by the weight of the robot, which is concentrated mainly in its chassis, and the distance between the wheels.

Most robots have a fixed screen and a fixed camera. This leads to the need to use a camera with a wide viewing angle, which is much more expensive than conventional cameras, and a second camera aimed at the wheels, which is necessary to avoid obstacles. Fixed screen and camera reduce the effect of presence, because when communicating "face to face" " the look" of the robot is not directed at the speaker. This problem is solved cardinally in the BotEyes-Pad robot, which allows you to change the angle of the tablet and camera by 120 degrees and use the same camera to watch its wheels.

Most robots have wheel control software installed on the same computer (usually a tablet) that is used for video communication. To reduce the number of wires that fit the tablet and spoil the design, wheel control signals are transmitted from the computer to the wheel controller via Bluetooth.

Video communication is based on WebRTC technology us rule. It also transmits wheel control signals. In contrast, the BotEyes-Pad robot uses Skype for video communication and WCF service to transmit wheel control signals over the Internet. This provides a number of advantages: Skype is familiar to more than half a billion people, the reliability and quality of Skype communication has increased significantly after the acquisition of its by Microsoft, which has made significant financial investments in the Skype infrastructure (in particular, super-nodes have been transferred to the Microsoft servers). In addition,

Skype is available by default in many modern TVs and they can also be used to communicate with the robot.

As a computer for controlling the movement, the robots typically use the same tablet, which is for video too. Only BotEyes-Pad robot to manage the wheel part uses a separate computer running Windows 10 IoT Core and using WCF service to manage user accounts and redirect information from the operator to the robot and back. Using of a separate computer for motion control allowed to isolate the tablet functions exclusively for video communication and to use for this purpose not only any tablet but even a smartphone without needs to install there robot specific software. For mechanical attachment of the gadget this robot uses a special design of the holder with adjustable grips. The division of functions between two computers also allows you to use not only Skype, but any video messenger you like, such as Google Hangout for example.

Remote control of all robots is usually performed either from a special application or from a web browser. The browser version is convenient because it does not depend on the platform and the type of gadget on which the browser is installed, and a separate application is more convenient because you do not need to type the address in browser address string. Robots using WebRTC are limited only by browsers that support it (as usual, work stably only with Google Chrome).

Payment for the use of Skype in the robot BotEyes-Pad is the limit of gadgets class from which you can control the robot: they must have the split screen feature because you need to open Skype in one side of the screen, and the control program for the wheel part in another one. This condition is satisfied by all desktop computers, windows-based tablets, iPad (but not iPhone), gadgets with Android 7 and above. In cases where the gadget does not support split screen, you can use "floating" browsers that run on foreground of Skype, have a transparency setting and which easy can be found in the Play Market. As an example, in Fig.3 the bottom right shows a view of the "control disk" of the robot that is opened in foreground of Skype in a "floating " browser with adjustable transparency installed on the Samsung Galaxy S6. The distance between the touch point of the screen and the center of the circle is proportional to the speed of the robot, the deviation of the touch point from the vertical line makes the robot rotate, touch on a yellow background causes a robot turning.



Fig. 3. Robot controlling disk opened in foreground of Skype in floating browser

Table 1. The main characteristics of widespread telepresence robots

Robot mark	Double 2	Beam+max	PadBot P2	BotEyes-Pad
Height	120-150 cm	134 cm	110 cm	125 cm
Weight	7 kg	22 kg	7 kg	10 kg
Screen size	10'	10'	10'	From 4' to 10'
Tablet	iPad	iPad	iPad	Any
Work from batteries	8 hours	8 hours	10 hours	10 hours
Screen tilt	no	no	30 deg.	120 deg.
Software	WebRTC	Private	?	Skype
Moving speed	2,88 km/h	1,44 km/h	2.6 km/h	2,5 km/h
Number of computers	1	1	1	2
Operator controlling from	iPad, iPhone, iPod touch, desktop computer	Smartphone, tablet, desktop computer	Smartphone, tablet	Smartphone, tablet, desktop computer
Features	Adjustabe height, smallest weight	The best design	foldable, auto docking	Works with Skype, foldable
Price on Amazon.com or telepresencerobots.com	\$2499 without tablet	\$4990 or \$2140 +year based subscription	\$1247 with tablet	\$760 without tablet

In robot computers sometimes they install additional software (like face recognition, text-to-speech, chat-bot), but these functions are not directly related to the telepresence and can be installed in a tablet of any robot.

All robots have a charging station (docking station), but not all come with them. Installing the robot on the dock usually does not cause any difficulties. However, a number of robots have the function of automatic installation on the dock.

### **Summary**

Areas of application of telepresence robots, allowing the market to grow, were not found immediately. They tried to use robots to attract people in wheelchairs to work, as a video-nanny, to monitor children in the kindergarten, at the school playground or at home in the absence of parents, to look after the house during the departure of the owners, to communicate with patients, for distance learning, to attend exhibitions, for video surveillance, etc. However, the market has made its choice and nowadays the vast majority of telepresence robots are used for remote work. This is probably due to the relatively high price of robots, which is only feasible for companies, but is not available in price to the average consumer.

The future of this industry is seen as follows: workers are at home, and their avatars (with hands and feet) - in the office of the company. Firms complete the staff regardless of the country or city in which their employees live. The language barrier is overcome by a gadget-translator with artificial intelligence.