

Spot Boston Dynamics Robot

Introduction to Robotics and Robots

Robotics is a branch of technology that handles the construction, application, design of robots and robot's sensory feedback, control, and information processing. The goal of Robotics is to make machines intelligent, to save time and reduce the efforts of humans in day to day activities and keep everyone safe. Robotics is an interdisciplinary research area that brings different branches of engineering to help create robots like Computer Science engineering for automation and software, Electrical engineering to build complex interconnected circuits, Mechanical engineering for physical design and actuation of robots, etc. Robotics creates machines that can do similar and even replace humans in specific tasks.

A robot is a machine that can be reprogrammable, multifunctional, manipulator to do tasks in a structured way like to move materials, tools, etc. The word Robot in Slavic means “Slave”. Robots are classified into pre-programmed, humanoid, teleoperated, autonomous, semi-autonomous machines. Autonomous Robots don't require human intervention to operate like the mars curiosity rover which operates autonomously without the intervention of NASA scientists to reach its final destination and Semi-Autonomous Robots needs partial supervision of humans on its actions like food delivery robots.

In recent years, Industry saw massive technological advancements in Machine Learning which in turn had a huge impact on robot automation. Many companies making use of this special ability to train a machine to think like a human in specific tasks like reading directions, analyzing audio for abnormalities, etc. With the increasing availability of data from a wide range of sensors in robots, they are becoming one step closer to humans in finding patterns and techniques in doing specific tasks like anomaly detection of sound, image, etc.

Robots are being used in different sectors like logistics, travel, healthcare, and home. Logistic robots are mainly commercial robots that are used in shipping, analyzing the quality, and handling of goods. Home robots are used to clean, secure, and maintain the house. Travel robots are using computer vision and artificial intelligence to detect and navigate in all types of travel medium. Healthcare robots are used to supervise patients, detect diseases in advance, analyzing health reports, etc.



In present times, the key sectors like the automotive industry, health care, and military are using heavily dependent on robots and machines. To cover most parts of the industries Boston Dynamics created Spot Robot which can be customizable to any kind of use case and environment.

Why Spot?

Spot is a quadruped robot developed by Boston Dynamics, An American Robot Designing company that can climb steps and navigates through rough terrain with unprecedented ease, and still, it is small that it can be used indoors. Spot is built to withstand critical industry conditions and has a customizable hardware and software platform. Spot has proven to have

the best autonomous sensing across different industries for remote operations. Spot is a flexible robot that can inspect dangerous, unapproachable, and remote environments, automate data collection in specific locations of that designated space and It can also carry payloads on unknown terrain.

Spot can be controlled with a joystick, mobile, and even by sending a set of actions using its API. It can do body posing, detect Anomalies in its path, has industry standard navigation, and inbuilt calibration. Spot's controller has a powerful feature that can create a predefined route for repetitive inspections to a particular place and creates a basic autonomous mission through Autowalk.

Spot's true power can be achieved by its Software Development Kit (SDK) which can be used to create applications for teleoperation, payload integrations, and designing fully autonomous systems.

Spot's Applications

The versatile capabilities of Spot are adding value in different industries ranging from energy, mining, entertainment, oil and gas, utility, public safety, and research. Many industries are trying to make use of Spot's state of the art technology.

Telemedicine – Spot can deliver medicine, food, and even conduct virtual patient interviews using a tablet mounted on its back. During this COVID-19 pandemic, contactless delivery or Inspections have become important to reduce the risk of transmitting the virus. Boston Dynamics is trying to piece together multiple technologies to achieve contactless operations using Spot. To detect respiratory rate and body temperature Boston dynamics team is attaching thermal camera technology to Spot. To measure pulse rate, they are capturing changes of blood vessel contraction by mounting RGB cameras externally to Spot. The use of Spot in public or hospitals proved to have great benefits in trying to get COVID under control.



Gauge Reading – To measure pressure, flow, temperature, etc. Spots takes colour pictures of analog gauges by using CAM payload. Machine Learning can be applied to find the readings with high accuracy rates. This process can limit the exposure of humans near the dangerous and risky parts of the factories.

Noise Anomaly detection – Spot can detect abnormal operating noises like whirring, ticking, or grinding by equipping it with a microphone or utilizing the one on the Spot CAM.

Thermal inspection – Spot can detect issues indicating hot spots on electrical conductors or hot spots with the thermal camera.

Gas, Radiation, and Leak Detection – Spot can be mounted with CAM, gas, and radiation sensors to detect hazardous places in disaster sites and nuclear plants and find invaluable equipment.

Tunnel Inspection – Spot can map entire sections of the tunnel using the LIDAR attachments. It can spot all the cracks and instabilities and makes the place safer for human inspection.

Research – NASA JPL used Spot and other Robots in DARPA Challenge Competition to navigate in rough and tricky terrains. NASA team CoStar has developed a holistic autonomy, communication framework, and perception called NeBula (Networked Belief aware of Perceptual Autonomy) to connect and establish a connection between Spot and other Robots. It has used all the capabilities of Spot to navigate quickly in building to map the interiors. The spot was been modified to fit the needs of the competition with a complete set of instruments on their back to maintain autonomous operations and to even connect other Spot Robots to share the information to save time and understand the environment.

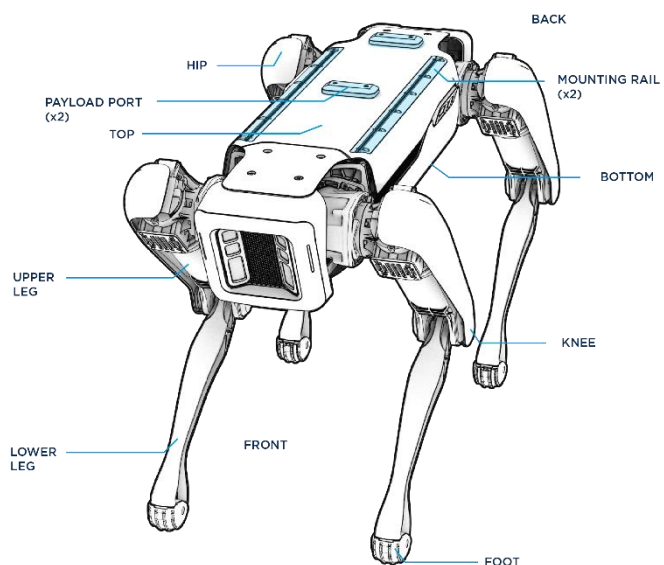


Spot's Hardware

Spot's base model can navigate itself through stairs, rough terrain, and has advanced mobility. Spot uses its inbuilt sensors to gather 2D and 3D data of its surroundings to navigate in any kind of terrain. Most of the sensors and hardware were designed by Boston Dynamics to fit the Spot's needs.

It is a mobile manipulated robot and can carry payloads weighing up to 14 kg. Spots 3D sensing capabilities are integrated with SLAM (Simultaneous Localization and Mapping) and obstacle avoidance system in the robot itself rather than depending on external processing hardware. The spot is an Omni-directional and multi-style trotting walking robot. It can balance and adjusts to physical disturbances with the help of multiple gyroscope and accelerometer sensors and its dynamic control is bioinspired.

It has one actuator in each knee and two actuators in each hip. Due to the presence of three actuators, it has a total of 12 Degrees of Freedom (DOF), 3 per leg. The dimensions of Spot are 43.3x500x33.1 with a net weight of



32.5kg. It has an average operating time of 90 mins with 605 Wh battery capacity. The battery weighs 4.2 kg and its standby time is 180 mins and the recharge time is 120 mins. The battery charger takes an input voltage of 100-240VAC with a frequency of 50/60Hz and a Max current of 5.5A and an output voltage of 35-58.6 VDC with Max current of 7.2A. It can climb slopes with +/- 30 degrees. It can go as high as 11.8 in of max step height. Spot has WIFI 2.4Ghz b/g/n and Gigabit Ethernet for Connectivity.

It can operate in -20 to 45°C temperatures and has IP54 ingress protection. It has a 360° horizontal field of view for a range of 4 m. It carries 20 projected stereo cameras with 8 in front and 4 on other sides. Spot does all the computation on on-device processor for finding a path or overcoming stationary and moving obstacles. Spot has a max speed of 1.6 m/s, the slope of $\pm 30^\circ$.

Spot can mount two payloads (which require ports) using DB25 connectors using the M5 T-slot rails mounting interface. It provides unregulated DC 35-58.8V and 150W per port. The integration of these payloads to Spot's on-device hardware (computation) can be done using its software API.

Spot can be adjusted to any use case and as of now, it has different payload options such as Perception, Computation, Autonomy, Manipulation, and Integration.

Spot's Perception Cam is used to make situation awareness better by having a colour feed, a 30x pan-tilt-zoom camera, and 360° FOV (Field of Vision). It has two-way audio and LED's to Enhance operator Experience.

Spot Computation Core is used to increase the computing power of Spot for better on-device locomotive, Navigation, and Control. Spot Core can be integrated into other payload options making it a more versatile tool to have on the robot. It has two variants Core CPU and Core GPU. Core CPU brings additional intel i5 8th gen processor, 16gb RAM, and 512gb SSD. Core GPU brings Intel Xeon E3-1515M V5, 32 GB RAM, 480GB mSATA SSD and NVIDIA P5000 GPU.

Spot's Autonomy LIDAR can be added to increase the robot's autonomy to navigate through large, dynamically changing environments. LIDAR can be conjectured with CAM and CORE for better-enhanced autonomy and telepresence.

Spot Manipulation ARM can be attached to the robot to interact with the environment. The manipulation Arm is a six DOF (Degrees of Freedom) mechanism. It can be used to open/close doors, grab tools, and other equipment that weighs up to 4kg.



Spot's Software

The spot is designed by keeping in mind various use cases of companies for automating repetitive, intelligent, and dangerous tasks. Spot has one of the best user-friendly interfaces which can be learned in 15 seconds and also has one of the advanced software customization options. Boston Dynamics has developed a Software Development Kit (SDK) which was written in Python for Spot to give diverse features to its developers. SDK can be used to build custom applications and payload hardware. SDK can also access sensor data and integrate the

autonomy system of Spot. Developers can add payload with custom sensors or extra compute power for Spot through its various interfaces like mechanical, electrical, communication, and software.

Developers can make their application and design a custom UI to control Spot remotely and have a real-time visual of the site robot visiting. They can make Spot do body posing, velocity, and direction by sending the commands. One more special feature includes Autowalk which makes Spot from teleoperated to a semi-autonomous robot. This feature is an easy-to-use tool that allows users to play their missions on the control tablet itself. AutoWalk can also be used for automating inspections, better script performance, etc.

Behaviour trees can be obtained by programming actions on the recorded missions of Spot in specific points on the map. Upcoming missions of Spot can be made entirely autonomous in those planned routes. Using features of Autowalk and LIDAR, HoloBuilder (software company) has made an application called SpotWalk to take scans of the building's workplace to observe the progress of construction. HoloBuilder can stitch together a lot of data and forms structured images of before and after to better understand and collaborate in construction sites. SpotWalk helps create well-structured data of the surroundings and helps in applying the Machine Learning algorithms on it. HoloBuilder helps in finding the patterns and insights of construction changes by applying powerful models on the generated data from SpotWalk.

Vinsa (AI based company) began to make models out of the data from the spot to make and



train machine learning algorithms to understand surroundings and better able to integrate into the industry needs. It captures hundreds of different use cases of specific tasks and makes a model to quickly give real-time insights into that task. By automating and detecting the labour-intensive tasks such as analyzing analog gauges, facility inspections, anomaly detection on a production line, and monitoring tools and equipment. Spot can improve people's safety and reduce operational costs.

Just like Vinsa and HoloBuilder, many other companies are looking into Spot Software API and Hardware to make better software which can accelerate the industry's needs and automation.

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