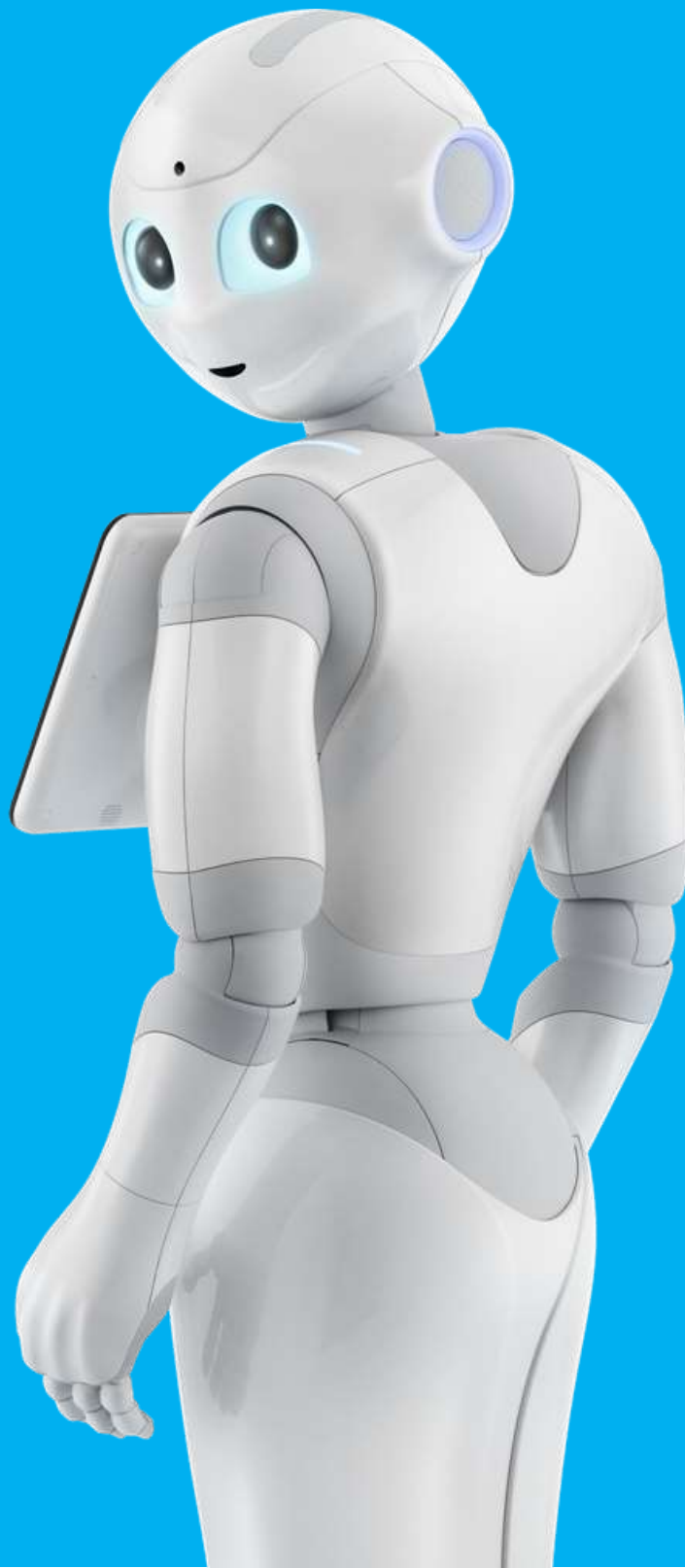


# pepper



Press Kit

# Meet Pepper

Pepper is a humanoid robot, engaging, surprising and above all kind. Pepper is the first emotional robot. He was not designed for an industrial function, rather to be a true companion for daily life with a first focus on affection.

Because of this, Pepper will truly change the way we live our lives.

## Emotional

Pepper is unique; a loyal friend, family member, and a kind accomplice. Are you sad, angry, happy? By the tone in your voice, the expression on your face, in your gestures and through the words you use, Pepper will progressively learn to detect your mood and adapt his behavior to relation to it. Pepper's main objective is to communicate with you. He has a certain personality and expresses his own "emotions" through the color of his eyes, his gestures and words he uses.

## Scalable

Pepper is much more than the newest tech product, he is an artificial creature that was designed to learn, evolve and surprise you a little more each day. Pepper currently requires some assistance: he does not know everything! You teach Pepper through your discussions which, today, help him memorize names, faces, moods, tastes and habits. Tomorrow, the evolution of Pepper will also be fueled by an application library which either you or Pepper will be able to access to find new behaviors, activities and content to inform, entertain or surprise you.

## Ultimate Interface

No need for a keyboard, mouse or screen, simply talk to Pepper, touch him or even approach him and watch him react. Pepper communicates the same way you do, through voice and gestures. This is an example of how technology is using the simplest and most intuitive form of communication we know.

## Interactive and Independent

Pepper is the first humanoid companion for the general public, able to interact in the real world and have a real presence among humans. His multiple sensors enable him to understand the world around him and adapt accordingly. Pepper can move, avoid obstacles, identify sounds, follow you and even recharge independently.

# Some facts on Pepper



- Elegant body 120 cm (47.3 in) high and 28 kg (61.7 lbs)
- 17 articulations for graceful movement
- 3 omnidirectional wheels for agile mobility
- Over 12 hours of energy when continuously active. Pepper even knows when his battery is low and will navigate to his charging station
- 30 innovative patents
- 1 3D camera to detect humans and their movement from up to 3m (9.8 ft) away

Pepper:  
Innovation  
personified

## A design that invites dialogue

At Aldebaran, the complexity of a robot should never be apparent. Our teams have paid particular attention to this point during the design of Pepper. The challenge lies in the ability to seamlessly integrate new technologies while enabling general acceptance of this new creature. Pepper is slender and with a fluid silhouette and no visible screws. His hands are similar to those of a human: the gripping system has been worked on resulting in five fingers with fingerprints to improve grip. The specialized gears developed for Pepper give him graceful movement while absorbing noise emittance. Three wheels at the base form a triangle and allow Pepper to move smoothly in all directions. The appearance of a machine disappears in favor of emotional interaction with the user. The simplicity of the design has been taken into account throughout the chain development for the life of Pepper. In the spirit of Aldebaran, the robot must be able to be repaired quickly and easily. Thus, arms and head are modular and can be changed in 30 seconds. From a very simple jack system a wheel can be changed in 2 minutes time.

## Strength and safety

Robot designers have also taken into account the safety aspects of Pepper. Pepper was designed to not be able to harm you: rubber parts cover most of the exposed joints, the hips, neck and head, protecting from pinching, rubbing and also absorbing shock. By simply pressing an emergency stop button, you can cut all electrical power to Pepper. The robot will turn off but even then will retain his balance through elastomeric strips located at the hip and stop in his center. In addition brakes allow him to maintain his standing position. On the other hand, in a case where he is shaking hands, Pepper is able to regain

and keep his own balance through a 'push recovery' system where he compensates with his wheels and his inertial measurement units.

## Emotion to understand you

Pepper has the ability to interpret basic expressions of emotion on the human face: a smile, frown, look of surprise, anger and sadness. He also knows how to understand the intonation of the voice, the context of words, as well as nonverbal language such as the tilt of the head. Coupling these interpretations allows Pepper to determine whether the person in front of him is in a happy or sad mood, with a valuation scale between the two states. The goal is to bring Pepper to really understand and adopt his reaction to fit your mood. One can imagine tomorrow Pepper will be able to sense you are sad and offer to play a song you like or even tell you a joke; or he could detect a smiling face and offer to play with you. The robot is in tune with you. As Pepper continues to recognize you, he will start to develop a memory of your relationship together, he will not ask you the same things twice, and gradually create an emotional connection to become your daily accomplice.

Pepper is gifted with a capacity for additional sharing through the tablet that is placed on his heart. This tablet can display additional information to enrich your interaction and reflects the world inside Pepper. Pepper has a colossal database of questions and answers in Japanese, English and French. The voice recognition capabilities of the robot are locally processed then sent to the cloud, in case the robot does not hear or understand what was said. Of course, like a human being, Pepper does not understand everything and sometimes can make mistakes! Pepper's specific voice has also been the subject of in-depth work in regard to expressiveness with custom voices created for English, French and Japanese for better adaptation to the

culture of the country. The programming also allows users to choose three shades of different voices: playful, neutral or didactic.

## An engaging personality

The autonomy of Pepper is progressive; it improves day after day, leaving the person to enjoy discovering more of his new companion every day through teaching and playing together. Pepper is continuously awake, always conscious of his body and his environment. When Pepper is alone, he will take the opportunity to control his internal temperature by adapting his movements to avoid overheating of his engines. He also knows to check the battery level, and go by himself to his recharging station when it's needed. Pepper is able to avoid obstacles during his navigation, including those behind him, thanks to his ultrasound, laser sensors and 'bumpers'.

Pepper is an excellent communicator and nonverbal language is no secrets for him. Seeing a person 1.5m (5 feet) away, Pepper will willingly approach and encourage dialogue through voice and gestures. His capabilities of perception to touch are thanks to sensors on the top of his head, over his hands, and on his tablet. Pepper responds to touch: it allows you to know that he has seen you and he felt your touch. Depending on the context, and thanks to his decision engine, Pepper can proactively trigger applications and answer questions you ask him such as "do I need to take my umbrella today?" or "what are the new films out this week?"





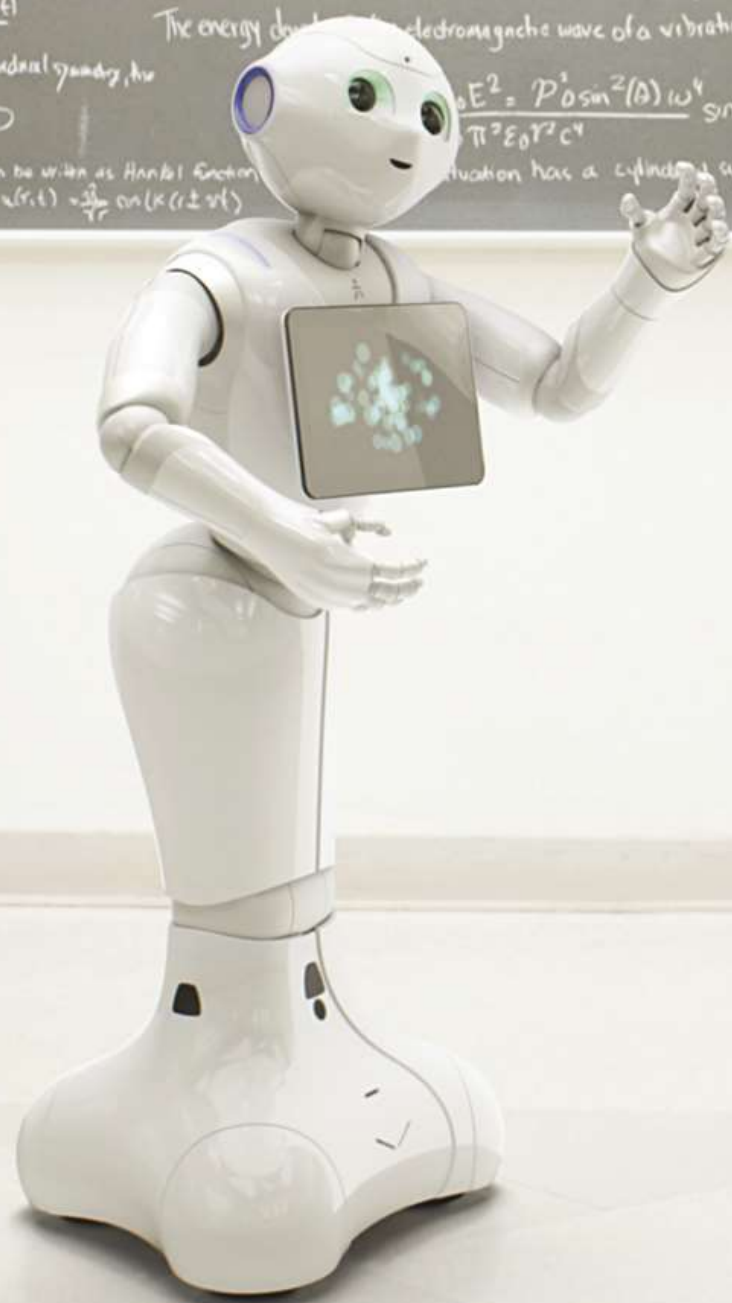
Doppler Effect. This is given by:  $\frac{f}{f_0} = \frac{v \pm v_{obs}}{v \pm v_s}$   
 Electromagnetic waves  
 Electromagnetic waves in vacuum  
 The wave equation  $\square \Psi(\vec{r}, t) = -f(\vec{r}, t)$  has the general solution, with  

$$\Psi(\vec{r}, t) = \int \frac{f(\vec{r}', t - |\vec{r} - \vec{r}'|/c)}{4\pi |\vec{r} - \vec{r}'|} d^3r'$$
  
 If this written as:  $\vec{J}(\vec{r}, t) = \vec{J}(\vec{r}) \exp(i\mathbf{k} \cdot \vec{r} - i\omega t)$   
 A derivation via multipole expansion will show that for the radiation  

$$\frac{dP}{d\Omega} = \frac{k^2}{32\pi^2 \epsilon_0 c^3} \left| \int \mathbf{J}(\vec{r}') e^{i\mathbf{k} \cdot \vec{r}'} d^3r' \right|^2$$
  
 The energy density of an electromagnetic wave of a vibrating dipole  

$$u = \frac{1}{2} \epsilon_0 E^2 + \frac{1}{2} \mu_0 H^2 = \frac{1}{2} \epsilon_0 E^2 \sin^2(\theta)$$
  
 Multipole expansion: Because  $\frac{1}{|\vec{r} - \vec{r}'|} = \frac{1}{r} \sum_0^{\infty} \left(\frac{r'}{r}\right)^l P_l(\cos\theta)$   
 Can be written as:  $V = \frac{q}{4\pi\epsilon_0} \sum_n \frac{e^{-i\mathbf{k} \cdot \vec{r}'}}{|\vec{r} - \vec{r}'|}$   
 For the bound-charge distributions this reduces to  
 The continuity equation for charge is  $\nabla \cdot \mathbf{J} + \dot{\rho} = 0$   
 The electric current is given by  $\mathbf{J} = \sigma \mathbf{E}$   
 For most conductors holds is the resistivity.  $\mathbf{E} = -\nabla\phi - \dot{\mathbf{A}}$   

$$\mathbf{A} = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}(\vec{r}', t - |\vec{r} - \vec{r}'|/c)}{|\vec{r} - \vec{r}'|} d^3r'$$



# The story of Pepper

# The meeting of SoftBank / Aldebaran

The next revolution of robotics and innovation is engrained in the DNA of Softbank, a large Japanese group with over 1,300 subsidiaries and affiliates worldwide. Once the decision was made in 2011 to invest in personal robotics, SoftBank identified several companies worldwide that might assist them with this mission. Aldebaran proved to be the most advanced and experienced actor in this market, since 2005, and was the creator of a very specific concept: to create emotional, kind robots to improve the lives of people. Aldebaran and SoftBank then created a shared vision: to initiate a new era with a class of interactive humanoid robots capable, as did the Internet, computers and mobile phones, to enrich and simplify our lives. To ensure Pepper's success in the world of personal robotics, SoftBank has chosen Aldebaran as the best partner for them for three main reasons: 1) the ability to create the best solution, 2) the ability to overcome the challenge of developing a robot in a short timeframe, and 3) the vision of a company established for 10 years on a whole new class of emotional and caring robots.

## Aldebaran

Founded by a French entrepreneur and lifelong robotics enthusiast, Aldebaran creates companion robots to help humans in everyday life. In less than 10 years, Aldebaran grew from a small start-up to the world leader in the humanoid robotics market, with robots being used in over 70 countries around the world. Today Aldebaran has about 450 employees with offices located in France, China, Japan and the United States.

In 2005, a handful of robotic enthusiasts created the company Aldebaran, drawing the name of the brightest star in the Taurus constellation. A year later the first prototype of their humanoid robot was born and named NAO. Thought to be an everyday companion, NAO was not yet finalized for this purpose but was already drawing attention by various academics and researchers.

In 2008 NAO was selected to succeed the robot dog Aibo as the standard league platform for the RoboCup Soccer league. This university competition organizes soccer matches between robots with a specific goal in mind: to have robots play against the (human) World Cup champions by 2050! Gradually NAO became a standard in the world of research and education.

Aldebaran's next major success came in 2010 when 20 NAOs were invited to dance in the France Pavilion at the Shanghai World Expo. NAO was the main attraction with the pavilion being visited by more than 10 million people. Over time, new versions of the robot were created with improved features. Through these evolutions the scope of educational uses for NAO continue to widen to include secondary education.

In 2011, ROMEO is born after two years of work in collaboration with research laboratories and institutions around Europe. This new robot, still only a research platform, aims to implement technologies in a larger sized robot to be able to physically help disabled people, at home or in nursing homes.

The year 2013 was marked by the launch of the ASK NAO program which offers a new educational approach for teachers to assist children with autism and other special needs through the help of NAO and specifically developed applications.

In June 2014, Aldebaran crossed into a new chapter by collaborating with SoftBank for the creation of Pepper, the first robot in the world able to read emotions. Present today in more than 140 SoftBank Mobile stores in Japan, Pepper greets, educates and entertains visitors. The sales launch to customers started in June 2015 in Japan with the first round of 1,000 units sold out in a minute! In parallel, Aldebaran opened a Developer Program for creating and distributing applications for NAO and Pepper.

Since March 2015, Aldebaran is moving towards a new phase in its development. SoftBank has invested in its capital up to 95% with the aim to make Aldebaran the overwhelming number one in humanoid robotics.

Pepper and his  
community of  
users

## Our programming tools

Aldebaran programming tools allow all users, from beginners to experts, to create behaviors for their robot. To do this, a development kit is available for maximum ease in applications creation. This kit includes a 3D simulator, simple to use and intuitive writing interface called Choregraphe and various SDKs in C ++, Python, Java and Javascript. To ease the utilization of these tools and allow Pepper to be proactive, Aldebaran has also developed its own operating system: NAOqi. NAOqi is an OS designed to facilitate natural interaction and emotion. Offering a new approach in human-machine interaction, NAOqi allows the robot to become an everyday companion. NAOqi is common to all robots from Aldebaran meaning that an application developed for a robot can easily be adapted to another.



## Contributing to the evolution of Pepper by inventing the uses of tomorrow

While main applications for Pepper are developed by Aldebaran, everyone is invited to create and develop applications using Pepper as a platform; not only developers. Animators, sound designers, graphic designers and linguists are also invited to join the Aldebaran community to invent and plan content to make Pepper more and more interesting. This is a new market that opens to a world of development and entertainment possibilities. Pepper will open up new uses for all humanoid robots thanks to his OS created by Aldebaran and tools created for easy programming. Developers working on Aldebaran robots will soon be able to submit and sell their applications on our Online Store by entering our Developer Program. Aldebaran and SoftBank also offer all the community the ability to learn and exchange with one another in our Ateliers, open in both Paris and Tokyo. These spaces which are open to the public allow all to discover Aldebaran robots, how to interact with them and how to program them.



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