MILITARY ROBOTS

The 2016 model of Boston Dynamics' "Atlas". It's what most people would expect a "robot" to look like but this is very much the exception!

Robots are increasingly being used in military applications where their most obvious advantage is the avoidance of danger to human soldiers. They can also do jobs that would be impossible for a human to do, such as tracking and shooting down an incoming supersonic missile.

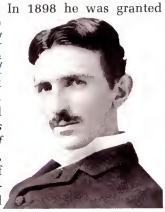
by DR DAVID MADDISON

Familiar examples of military robots, which may not be at first thought of as being robots, include remotely-operated tracked vehicles for destroying explosive devices, the autonomous Phalanx CIWS to destroy incoming missiles, cruise missiles such as the Tomahawk and surveillance and hunter-killer "drones" such as the surveillance Global Hawk and Heron (as used by the RAAF) and the armed MQ-1 Predator.

This list is expanding all the time and in this article we will discuss some past and present military robots and devices under development.

Nikola Tesla started it

Nikola Tesla laid the foundation for the first remotely operated machines. In 1898 he was granted U.S. Patent Number 613809 (**https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US613809.pdf**) for the first wireless remote control system.



The patent was entitled "*Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles*", and it covered "any type of vessel or vehicle which is capable of being propelled and

directed, such as a boat, a balloon, or a carriage."

He exhibited his "teleauto-mation" technology with a one-metre long battery-operated boat at an electrical industry trade show at Madison Square Garden where it was well received.

Tesla explained that he could easily build a larger boat, fill it with dynamite and steer it by remote control toward an enemy ship. Tesla also wrote that he could build a remotely controlled aircraft that "...could change its direction in flight, explode at will, and... never make a miss". In other words, he envisaged a flying bomb.

Tesla later went on to write in his book, "My Inventions" (1919), "*Teleautomats (robots as we now call them) will be ultimately produced, capable of acting as if possessed of their own intelligence, and their advent will create a revolution*".

In 1912, Tesla went into business with Jack Hammond to create radio-controlled torpedoes for the US Navy which were tested between 1914 and 1916 but the Navy did not pursue the idea.

The Hewitt-Sperry Automatic Airplane

The development of robotic remote controlled aircraft required three key technologies: 1) automatic stabilisation; 2) remote control via radio and 3) autonomous navigation.

In 1909, Elmer Sperry, famous for his work on gyroscopes, incorporated a gyroscope in a manned aircraft with a view to improving flight safety. The device performed poorly but it did coincidentally enable a way to provide stability for an unmanned aircraft. In 1911, he revisited the problem, encouraged by aviation pioneer Glenn Curtiss. He coupled a set of 3-axis gyros to a plane's flight controls via servo-motors.

In 1912, Curtiss tried to interest the US Military but after several crashes, the US Army were no longer interested. For their part, the US Navy was not interested because they thought the system was no substitute for a pilot. In 1914 Sperry's gyro-stabilised plane won a French prize but two weeks later war broke out and attention was diverted to other things.

The Curtiss-Sperry Aerial Torpedo, demonstrated in 1916.

In 1915, Peter Hewitt saw potential in Sperry's invention to fulfil Tesla's 1898 concept of a flying bomb and wanted to co-develop such a device with him. However, they ran out of money until they received funding from the US Navy to develop an "aerial torpedo".

The guidance system for this aerial torpedo was demonstrated in 1916 where a manned aircraft was flown automatically over a set distance and then commanded to dive as would be required for the aerial torpedo. The pilot then took over the controls, recovered from the dive and returned to base. This aircraft was based on the Curtiss N-9 seaplane and became known as the Hewitt-Sperry Automatic Airplane. It was not accurate enough to hit a ship at sea but in 1917 the US Navy recommended its continued development.

There were two strands to the aerial torpedo program. One was to develop an autonomous version that would fly a predetermined distance and then dive onto the target. The other was to remotely control an aerial torpedo from another aircraft. The US Navy wanted to use the aerial torpedoes against German U-boats, U-boat bases and factories from distances of up to 160km. By November 1917 distances of 48km were being achieved with an accuracy of 3km, not exactly precision guidance by today's standards but impressive for the time.

Essential to the radio control of the aerial torpedo was the Audion vacuum tube which was the first triode device. It was able to efficiently amplify a radio signal, unlike previous devices. A version of the Audion was developed for the radio control equipment in parallel with the aerial torpedo. The wireless radio control system was patented and the patent can be viewed at https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US1792937.pdf "*Wireless-Controlled Aerial Torpedo*".

The Curtiss-Sperry Flying Bomb

It then became clear that the Curtiss N-9 seaplane was not an efficient enough platform. An order for six different specialised airframes for the aerial torpedo was made in October 1917 and it became the first purpose-built unmanned

Nikola Tesla tries to prevent WW2 and makes a prediction about the future of war

Tesla wrote this some time in the 1920s but it was not published at the time.

"At present, many of the ablest minds are trying to devise expedients for preventing a repetition of the awful conflict which is only theoretically ended and the duration and main issues of which I have correctly predicted in an article printed in the Sun of December 20, 1914.

The proposed League is not a remedy but, on the contrary, in the opinion of a number of competent men, may bring about results just the opposite. It is particularly regrettable that a punitive policy was adopted in framing the terms of peace, because a few years hence, it will be possible for nations to fight without armies, ships or guns, by weapons far more terrible, to the destructive action and range of which there is virtually no limit.

Any city, at a distance, whatsoever, from the enemy, can be destroyed by him and no power on earth can stop him from doing so.

If we want to avert an impending calamity and a state of things which may transform this globe into an inferno, we should push the development of flying machines and wireless transmission of energy without an instant's delay and with all the power and resources of the nation."

The Soviet Reno-russky shown in Red Square.

aircraft, to be known as the Curtiss-Sperry Flying Bomb.

With an empty weight of 227kg, it could carry an explosive payload of 454kg and had a range of 80km, at a top speed of 145km/h. With the war coming to its end and with some technical issues with the airframes and other test failures, the US Navy discontinued work with Sperry and Hewitt.

Instead, it engaged other companies to develop airframes and autopilots and shifted emphasis on remotely operated or autonomous aircraft away from aerial torpedoes to their potential use as target drones.

Nevertheless, the Curtiss-Sperry Flying Bomb goes down in history as the world's first cruise missile.

The Russian Teletank

In 1927 the Soviet Central Laboratory of Wire Communication developed radio control equipment for a tank. This equipment was installed in a French Renault FT light tank design (otherwise known as the FT-17), nicknamed the "Reno-russky".

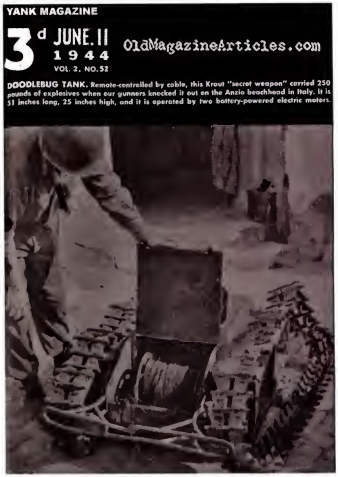
Military robots in World War 2

Military robots were first used in anger more than 70 years ago, in World War 2. The Soviets used the Teletank, the Nazis used the Goliath tracked mine and the Americans developed a bomber into a remote-control precision guided munition under the auspices of Project Aphrodite and they also developed an "attack drone" known as the TDR-1.

The Teletank design used by the Soviets in World War 2 were based on one of several designs and operated via wireless remote control from a manned tank at range of 500-1500 metres. The remotely operated tanks had the designation TT and the control tanks TU.

Apart from Soviet designs based on the French Renault

TU-26 control tank (left) with paired TT-26 Teletank (right) in the Ukraine in 1941. A total of 162 TU-26 and TT-26 tanks were manufactured.



Cover of Yank Magazine of June 11th, 1944 showing a Goliath found by GIs. The GI nick-name for the vehicle was the Doodlebug – a colloquial name more commonly used by Londoners for the V1 flying bombs (see elsewhere in this feature).

FT, there were others based on the British Vickers 6-Ton Tank, the French AMR 33 and a design based on the suspension developed by American J. Walter Christie.

Teletanks were equipped with a variety of weapons and could also deliver a large explosive charge of up to 700kg near enemy fortifications in order to destroy them. Teletanks could be controlled by between 16 and 24 commands, depending on the model and two radio frequencies could be used; the second frequency was selected if the first frequency was jammed.

For recollections of a Teletank operator of WW2 along with some technical information about the radio control mechanism you may wish to look at the blog post at www.armchairgeneral.com/forums/showthread.php?t=132961

The Goliath tracked mine

The Goliath tracked mine (known to the Allies as the Beetle Tank) was a small control-cable operated robot used by the Nazis in WW2. It was designed for general demolition and disruption work and could carry 60 or 100kg of explosives, depending on the model.

It was joystick-operated via a 3-strand, 650m long cable with two wires used for steering and forward motion and the third wire used to detonate the explosives.

Earlier models had electric motors and later models had a more reliable petrol motor. Its weight was 370kg for the

Goliath tracked mine of WW2 Germany at Vadim Zadorozhny's Vehicle Museum in Arkhangelskoye, the largest private collection of vehicles in Russia. Note motorcycles for size comparison. (http://tmuseum.ru/main-page)

electric model or 430kg for the petrol model.

Although over 7,500 of these devices were made, the Goliath was not considered a success. This was due to its high cost, complexity, vulnerability of its body and control cable, its slow speed of just 10km/h and inability to negotiate rough terrain.

Another disadvantage was that there was no way for the operator to get a view of the areas surrounding the vehicle.

A video of the Goliath can be seen at **https://youtu.be/zhK8L0PgPdA** "*Goliath Demolition Tank*".

Note that in this war-time video, they refer to one model as being radio-controlled although the control cable is shown and they also refer to a larger model that can drop off an explosive payload and return to base under radio control. This might well erroneously refer to the Soviet Teletank mentioned above.

Operation Aphrodite

Operation Aphrodite was an American program of late WW2 to take out hardened German super-gun sites, U-boat and V-weapons sites. The idea was to take B-17 and B-24 bombers that were beyond useful service life, strip out as much as possible to save weight (about 5400kg of equipment was removed), add remote controls, fill them with explosives and fly them to their targets.

The aircraft was loaded with around 9000kg of British Torpex explosives which were 50% more powerful than TNT. It was hoped that this program would give the US a capability that the British had with their Tallboy and Grand Slam ground penetrating bombs.

The remote controls consisted of radio control from a chase plane and two television cameras, one to look at the flight gauges and another to look ahead to be viewed by the controlling pilot. The television signal was transmitted to the chase plane.

The remote controls were not sophisticated enough to perform a take-off, so volunteer pilots flew them until they were in stable flight at 10,000ft and then parachuted out. The volunteers received a battle credit of five missions for this one take off, plus a Distinguished Flying Cross.

The program was a failure and none of the 14 missions flown resulted in any intended target being destroyed. There were many pilot deaths, one of which was Joseph Kennedy Junior whose aircraft exploded in mid-air before he and his colleagues had time to parachute out. A junior electronics officer had tried to warn about a wiring fault the previous day but was not listened to and it is likely that this defect cause the premature explosion.

For some video of Operation Aphrodite see **http://channel.nationalgeographic.com/the-strange-truth/videos/WW2s-operation-aphrodite/** "*WW2'S OPERATION APHRODITE*" and **https://youtu.be/BTibIDZhAOg** "*Operation Aphrodite 1940s Remote Control Airplane as Bomb*".

TDR-1 assault drone

The TDR was an unmanned, radio controlled "assault drone" developed during WW2 for the US Navy.

The idea for a remotely piloted aircraft for Naval combat operations had been proposed as early as 1936 but it wasn't until the development of the radar altimeter and television that this project became feasible.

The TDR first flew in 1942, was introduced in September 1944 and was retired from service in October 1944. Only 200 of 2000 ordered units were built.

It was designed to carry bombs or torpedoes and was controlled via a radio and television link from a chase aircraft. For testing purposes, the vehicle could be piloted but for normal operation the cockpit canopy was removed, improving its aerodynamic properties.

In order to minimise consumption of strategic war materials the frame was fabricated in tubular steel by the Schwinn bicycle company and it had a moulded wood skin.

A total of 50 drones were flown in combat, 37 of which reached their targets.

There were some problems with the aircraft which, combined with the success of conventional warfare operations, meant that this project was not regarded as a great success.

For a video of test footage of the TDR-1 see **https://youtu.be/CwS669Ipgwc** "*U.S. NAVY WW2 TDR-1 DRONE OPERATIONAL TESTS IN SOUTH PACIFIC 30772*".

German V1 "Doodlebug"/"Buzz bomb" and V2

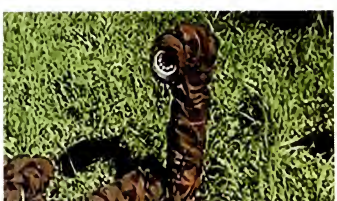
Another early "drone"-type aircraft was the German V1. It was a rudimentary cruise missile. It looked like a plane

A robot kills a domestic terrorist

Over 2000 terrorists have been killed by US military aerial drones but recently in the US for the first time a domestic terrorist was deliberately killed by a robot. The terrorist killed five police officers in Dallas, Texas on June 7th, 2016 and would not give himself up so police judged that the only way to neutralise him was to deliver an explosive charge, normally used to detonate bombs, to his location.

The robot used was the Andros Mark V-A1 made by Northrop Grumman and was used to deliver about 450g of C-4 detonation cord to the target. Note that the robot did not operate autonomously; it was radio-controlled. It has not been stated whether the robot was damaged in the incident.

For a (silent) video of this model of robot in operation see **https://youtu.be/w7W3Kd9Cr-s** "Remotec Andros Mark 5A-1- Bloomington Mn Bomb Squad July 3, 2012 ".



Snake Robot in its natural habitat. Note how the robot has its body raised to get a better view with the head mounted camera.

The MAARS Robot is equipped with a quad tube 40mm grenade launcher which can be loaded with lethal or non-lethal ammunition, along with a medium machine gun.

and was powered by a pulse-jet engine that run on petrol and was stabilised by a gyroscope.

Essentially, it was pointed in the direction of the target (often London) and launched off a ramp. It would then fly to the target, dive and explode on impact. The location to dive was determined by measuring the flight distance with an impeller. The first of over 10,000 was launched in June 1944. At times, more than 100 hit London in a single hour.

While not normally considered a "robot", its successor, the V2 ballistic missile, was also autonomous after launch. In fact, modern ballistic missiles perform quite complex tasks autonomously including mid-course corrections, separation of multiple warheads with independent targeting and even deploying countermeasures such as chaff and flares designed to confound attempts to intercept the warhead(s).

Later Soviet Teletanks

In 1966 the Soviets developed the T55-based Teletank which was called the VNII-100. A video of it can be seen at http://shvachko.net/teller/wp-content/uploads/2012/03/Teletank_T-55.mp4

In 2000 a robotic T-72B tank was developed and it can be seen at http://shvachko.net/teller/wp-content/uploads/2012/03/Teletank_T-72B.mp4 The videos are narrated in Russian but are still informative to watch.

Current military robots

Military robots can usually be loosely categorised by to their function, such as surveillance, troop assist, self defence, attack, area patrol, hazard disposal, obstacle clearance or search and rescue. Sometimes military robots fall into more than one of these categories, as the following examples will show.

Snake Robot

While the present developmental status of this system is unknown, in 2009 Israel demonstrated a 2m long robotic snake that could crawl through long grass and raise its head when necessary, crawl over or under obstructions and crawl into pipes. Designed by Technion, it is equipped with a camera and microphone and is controlled via a laptop.

The snake is capable of being equipped with explosives so it could slither up to an enemy position and detonate. Another possible use for this robot is to crawl into collapsed buildings (due to an earthquake, for example) to look for survivors.

This snake robot provided the inspiration for a 2013 medical robot for keyhole surgery known as the Flex Robotic System.

For a video of the snake in action see https://youtu.be/1JnQL7mjspg *"Israeli Military Testing 'robotic' Snake"*.

Surveillance and attack

The Modular Advanced Armed Robotic System (MAARS) produced by QinetiQ in the USA is a tracked unmanned ground vehicle (UGV) "designed expressly for reconnaissance, surveillance, and target acquisition (RSTA) missions".

The robot can operate at up to 1km from the operator and its sensors incorporate multiple on-board day and night cameras, motion detectors, an acoustic microphone and a hostile fire detection system. It can also provide warnings to an enemy via a loudspeaker system or a siren.

The device can carry a variety of payloads from non-lethal to "less than lethal" or lethal, as follows:

Non-Lethal – Audio deterrent (operator's voice through on-board loudspeakers), pre-recorded messages, siren, eye-safe lasers to disorient and confuse.

Less-Lethal – 40mm grenade launcher with the following grenade capabilities: sponge round, buckshot, tear gas, smoke or flare/illumination rounds.

Lethal – 40mm grenade launcher with the following grenade capabilities: high explosive (HE), high explosive dual purpose (HEDP), high explosive air burst, M240B medium machine gun with 450 rounds of 7.62mm ammunition.

The robot can also tow cargo such as a slide (as per the video) or trailer carrying an injured soldier or other equipment. It has a battery life of 3 to 12 hours or can be put in a sleep mode for up to a week. A human is required "in the loop" to operate any weapons system.

For a video of MAARS in action, see https://youtu.be/bczyYHcSu98 *"MAARS Modular Advanced Armed Robotic System"*.

PackBot

The PackBot 510 by iRobot (the same company that makes the Roomba robotic vacuum cleaner!), is one of

The Packbot 510, one of the most widely-used military robots in the world with over 4500 in service.

the most widely used military robots in the world. It is a tracked robot with a wide variety of options to enable it to be used for missions such as bomb disposal, including roadside IEDs, surveillance and reconnaissance, searching of buildings, caves and tunnels etc.

Over 4500 Packbot 510s are in use worldwide. The robot is controlled via a game-style hand controller. To overcome limitations of line-of-sight communications, it can also employ an optional mesh radio kit with multiple nodes to relay communications.

Other features include an ability to retrace its steps and return to base if communications are lost. It can right itself if flipped over, can maintain a set heading and make adjustments for going over debris etc. On one battery charge it can travel around 16km in four hours.

Among numerous optional accessories are an "Enhanced Awareness Payload" which includes a wide-angle video camera, different manipulator arms, an explosives detection kit, thermal camera, HazMat detection kit, route clearance kit and cable cutters.

This robot is battle-proven with 2000 having been used by coalition forces in Iraq and Afghanistan. They were also used to inspect the Fukushima nuclear plant.

Missile defence robots

The Phalanx CIWS (close in weapons system), an autonomous military robot, is designed to shoot down incoming anti-ship missiles and defeat small surface vessels from a ship by firing 20mm projectiles from a six-barrel gun at a rate of 4500 rounds per minute at a muzzle velocity of 1100 metres per second.

It is possibly the only example in current use of a fully autonomous military robot because once it is armed, all of its functions are fully automatic. There are also lessons to be learned in respect of its autonomy, as illustrated by the following incident.

In 1989, during a US Navy exercise off the East Coast of the US, the Phalanx system successfully engaged a target drone and destroyed it but as the debris was falling to the ocean the Phalanx interpreted the falling debris as a threat and re-acquired it as a new target. As the debris fell close to the surface of the ocean rounds from the Phalanx were still being fired on the "target" and struck a ship behind the target, killing one officer and injuring another.

The Phalanx CIWS (Close In Weapons System) looks a little like R2D2 from Star Wars and is regarded by some people as a lethal autonomous weapons system (see box).

Presumably the software has been upgraded to avoid such incidents, as the software and hardware are under continual improvement.

See **https://youtu.be/Zdp9llrBLnA** *"Raytheon - Phalanx Close-In Weapon System (CIWS) & SeaRAM Anti-Ship Missile Defense System [480p]"*.

A more recent development of CIWS is the Centurion C-RAM, which stands for "counter-rocket, artillery and mortar". It is a land-based version of the Phalanx which operates autonomously to defend a base against artillery attack.

In use since 2005, the Centurion is mounted on a trailer with a generator for power and uses its radar to detect and track incoming projectiles and attempts to destroy them before they land. It operates autonomously and uses self-destructing ammunition to avoid damage or injuries when rounds that miss their target fall back to Earth. The Centurion system defeated over 100 attacks on US bases in Iraq.

More recently, Israel have fielded the "Iron Dome" anti-rocket system which uses guided missiles to destroy incoming rockets. As such, it can engage larger targets at longer ranges over a wider area however the missiles are significantly more expensive than ammunition for the Centurion. Iron Dome also operates largely autonomously, since the time between the detection of an incoming rocket and its impact is typically measured in seconds.

Rheinmetall of Germany produce an automated base

Centurion C-RAM is a land-based version of Phalanx, used for automated base defence against artillery.

MANTIS C-RAM provides autonomous base defence and has been used by Germany since 2010.

The G-NIUS Guardium is a fully autonomous vehicle which can patrol a route, detect and fight off intruders.

defense system known as MANTIS Skyshield C-RAM, consisting of up to six automated turrets and two radar systems.

IAI Katana unmanned surface vessel

The Israel Aerospace Industries Katana is an unmanned (or optionally manned) surface vessel designed for homeland security and naval applications. It is controlled from a land-based mobile station or one on a mother ship.

The purpose of Katana is to patrol shallow coastal and territorial waters, engage in surface warfare and electronic warfare, provide harbour security and security around offshore oil and gas installations, to protect areas around undersea pipelines and to patrol a nation's offshore Exclusive Economic Zones as well as patrol for illegal immigrants or enemy combatants.

Katana is designed to avoid collisions and navigate and operate autonomously when required. It is capable of detecting, classifying, identifying and tracking a variety of targets. The system can be equipped with a variety of communication, electro-optical, radar and weapons systems and can also be operated via satellite so can work anywhere in the world.

The vessel is 12 metres long by 2.8 metres wide and has a top speed of 60 knots (110km/h) and is driven by two 418kW engines. Its range is 648km. It can be equipped with a variety of non-lethal or lethal weaponry. If desired, the Katana system can be retrofitted into an existing platform.

IAI Katana unmanned surface vessel, with its command and control station inset top right.

For a video of the Katana in action see **https://youtu.be/sOzBpOQNOIU** "*KATANA Unmanned Surface Vessel*". A similar vessel from Israel is from competitor Rafael and is called the Protector. See **https://youtu.be/hUPY5YZhT1Q** "*Rafael Protector USV*".

G-NIUS Guardium

The Guardium is a four-wheeled vehicle which can operate in fully-autonomous or semi-autonomous mode. It is equipped with sensors and can carry lethal or non-lethal weapons. It is already in use by Israel in the border-patrol role. Multiple vehicles are able to co-ordinate with each other. It has been in service since 2008.

Guardium is armoured to withstand attack and has several days' endurance for long-range missions. It can carry cameras, infrared cameras, radar, microphone and hostile fire detectors. The sensors allow it to patrol a pre-defined route while avoiding obstacles, surmounting difficult terrain and monitoring for intruders along the route.

BAE Systems Multi-Operated All-Terrain Vehicle (MOATV)

Soldiers have to often carry very heavy loads which limits their mobility and endurance. The MOATV is designed as a vehicle onto which soldiers can place their heavy packs and other loads in order to relieve them of that burden.

The MOATV can be operated in a number of modes such as simply following a soldier or group of soldiers as they walk along or it can be remotely operated or alternatively, it can be operated semi-autonomously whereby a target location is set and the robot navigates along roads or around obstacles. It could also be loaded with casualties which could be automatically returned to base for treatment.

A similar robot to this is the Lockheed Martin SMSS (Squad Mission Support System).

Who is the enemy?

Military robots can be either remote-controlled or semi-autonomous. Semi-autonomous robots are smart enough to determine which path to take but until now there has

Faception analysis of the Paris terrorist attacks. Traditional facial recognition software could detect three terrorists in a database. When the video surveillance of the attacks was analysed (using no prior knowledge) with Faception software it detected nine terrorists including two already in the facial recognition database and failed to classify two, one of which was in the database. Had the software been running live at the time it could have detected nine of the eleven terrorists.

been no way machines could distinguish the good guys from the bad guys.

Israeli company Faception (www.faception.com) has developed facial analysis software that can determine, without any prior knowledge of a person, whether or not they are a terrorist, for example. It does this based on facial characteristics alone and a suspect does not need to be in a database, ie, it is not just a matter of matching a face to an existing database entry.

Faception can work with still images or live video streams. Apart from being able to detect terrorists with a high level of accuracy, once the software has been trained it can classify faces according to any other number of descriptors such as extroverts, people with high IQs or "poker players" so apart from law enforcement, it has any number of other possible uses.

The theory of operation of this software is that personality traits are reflected in facial features. This connection was proven in a research paper that can be seen at www.researchgate.net/publication/44614706Internal_facial_features_are_signals_of_personality_and_health

Researchers Kramer and Ward showed in 2006 that four of the so-called Big Five personality traits were reflected in facial features. The Big Five personality traits are openness to experience, extroversion, agreeableness, neuroticism and conscientiousness (the one trait found not to be reflected in the face was conscientiousness).

For centuries the Chinese have believed that a person's personality can be read from their face.

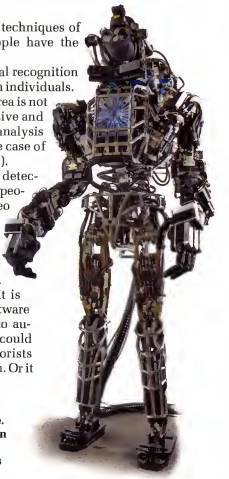
The main advantage of Faception is that it can detect a suspicious person based on only their facial appearance.

In contrast, conventional techniques of detecting suspicious people have the following disadvantages:

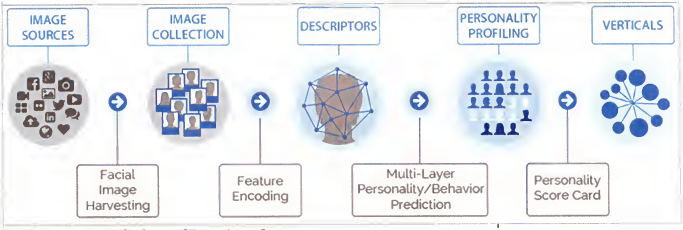
Fingerprinting and facial recognition are only suitable for known individuals. Video surveillance of an area is not focused and labour intensive and usually only useful for analysis after an incident (as in the case of the 7/7 London bombings).

Suspicious behaviour detection software that analyses people's movements from video feeds and detects if they have been loitering for an inappropriately long time can be tricked and "profiling" can be subject to bias.

Looking to the future, it is conceivable that this software could be incorporated into autonomous robots which could patrol areas, detect terrorists and take appropriate action. Or it



The early version of Atlas, complete with power cable. The later version (shown on page 22) runs on internal power and its "skeleton" is covered.



▲ Above: operational scheme of Faception software.

Right: a comparison of the Faception ▶ software to traditional facial recognition software.

CHARACTERISTIC	FACE RECOGNITION BASED	FACEPTION Facial personality profiling
Objective	Identify or verify an individual (known)	Reveal an individual personality (anonymous)
Input	Facial image	Facial image
Prior knowledge required	Up-to-date facial image of individual	None
Technology used	Similarity-based search & match	Trait/behavior classifiers
Output	Degree of match to a known individual	Degree of match to a set of traits/behaviors
Action	Apprehend and detain	Increase attention level, search/investigate/follow

could be incorporated into personal robots that could interact more effectively with their owners by reading their faces.

For a video explaining how the software works, see https://youtu.be/x1QsDiWCV-o "*Faception pitch 2 min*".

Robots under development

We will now look at some novel robots currently under developments which are not simply more advanced versions of those machines or themes discussed above.

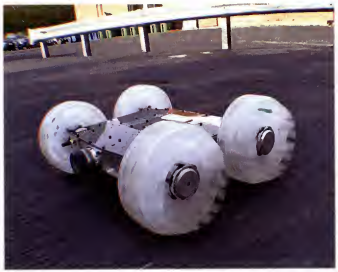
Boston Dynamics Atlas

Atlas is a bipedal humanoid robot developed by Boston Dynamics, a company now owned by Google. Atlas was first unveiled in 2013 but an improved version was released this year. The new version runs on internal power and has LIDAR and stereo video sensors to develop a 3D view of environment in order to autonomously navigate. Its movement is very human-like.

The primary role for this robot is to perform operations such as moving objects, turning on or off valves or opening doors in hazardous environments not suitable for humans. It is intended as an aid to emergency services and even though it is funded by the US Department of Defense, they have stated they do not intend to use it in combat operations although there is obvious potential there.

To fully appreciate the amazing capabilities of this robot it is best to watch the suggested videos.

The earlier version of Atlas can be seen here: https://youtu.be/WYKgHa8hH1k "*Boston Dynamics - Atlas Robot Rocky Terrain & Balancing Tests Update [720p]*".



Boston Dynamics Sand Flea, which can jump 8m.

Sand Flea in multiple exposure showing jumping action.

WildCat quadruped robot (above) and "galloping" across a field (right).

For a video of the latest version of Atlas in operation see https://youtu.be/rVlhMGQgDkY "*Atlas, The Next Generation*".

Boston Dynamics Sand Flea & Wild Cat

Sand Flea is a small wheeled robot with a camera which has one unique capability to jump as high as 8 metres in order to clear obstacles, jump onto roofs, up vertical embankments or through open windows.

During flight it is gyro-stabilised to keep it level. It weighs about 4.9kg.

It has batteries for drive and a gas cylinder to provide power for jumping which give an endurance of 2 hours and 25 jumps. It is being funded by the US Army. See the Sand Flea at https://youtu.be/6b4ZZQkcNEo "*Sand Flea Jumping Robot*".

WildCat is a free running quadruped robot that can run at up to 26km/h (powered by a very noisy 2-stroke motor!). Its purpose is to explore ways in which quadruped robots could be used by the military, especially to move supplies over rough terrain. One example would be to carry troop backpacks or other supplies.

BAE Systems Taranis, unmanned combat aircraft system advanced technology demonstrator.

Other reading

SILICON CHIP has previously looked at military robots:

"The Avalon 2013 Airshow" in the May 2013 edition. Robots covered included the Northrop Grumman MQ-4C Triton UAV and the Heron UAV as used by the RAAF.

"The Autonomous Ground Vehicle Competition" in the April 2014 edition, covering the Phalanx CIWS to destroy anti-ship missiles and the G-NIUS Guardium MKII Autonomous Ground Vehicle.

"The Australian International Airshow 2015" in the May 2015 edition. mentioning the MQ-8C unmanned helicopter, the MQ-4C Triton UAV, the Aersonde Mk4.7 UAV and AAI RQ-7B Shadow 200 UAV, the Silvertone Electronics Flamingo Mk1 UAV and the MQ-9 Reaper UAV.

Also see articles by Bob Young in July 1999, April, May & June 2001 and June 2010.

See WildCat at https://youtu.be/wE3fmFTtP9g "*Introducing WildCat*".

Boston Dynamics LS3

The LS3 (for Legged Squad Support System) is a system designed to assist troops by carrying up to 180kg of equipment. It reached a sufficiently high level of development that it was used by the US Marines in exercises.

It had a high level of reliability and if it fell over it could right itself most of the time but it was unable to traverse certain types of terrain. Another problem was that its motor was quite loud.

This robot, which cost US$42 million to develop, was not accepted into service but the potential remains for this type of robot to assist troops in the future.

You can see the LS3 at https://youtu.be/OYs0Rq66-U4 "*Boston Dynamics LS3 Military Robot Delivering Water to U.S. Marines*" and https://youtu.be/pZu-xWX4Buk "*LS3 Robot Patrols With Marines, Comes Under Simulated Mortar Attack*".

Mind you, these videos also show that these machines have a long way to go if they are to be really useful on the battlefield.

BAE Systems Taranis

The BAE Systems Taranis is an unmanned combat aerial vehicle that can search for, locate and identify enemy targets but at present requires a person to give permission to fire. It currently is not fully autonomous but could be made to be. It can also defend itself against attack.

(Incidentally, its first flight was at Woomera, SA in 2013).

It is designed for long-range intercontinental missions, can attack aerial or ground targets with a variety of weapons stored in two internal weapons bays, utilises stealth technology and is linked to a ground control station via satellite.

The aircraft is 12.4m long with a wing span of 10m and it has a maximum take off weight of about 8000kg.

Concluding remarks

Military robots are developing at a rapid rate and could provide the option of making warfare safer for the side employing them by removing soldiers from the most hazardous situations.

The overall trend is that the robots are becoming more autonomous and more lethal. SC