Optoelektroniczne systemy metrologiczne, naprowadzanie na wiązkę laserową i prowadzenie w wiązce - SMK

1. Dalmierze laserowe

1.1. Dalmierz laserowy - (ang. *laser target marker / range finder*; LTM) urządzenie do określania odległości od nieprzezroczystego obiektu przy pomocy promienia lasera. Pomiar odległości polega na wysłaniu promienia lasera w kierunku obiektu i zmierzeniu czasu po jakim odbity promień powróci do nadawcy. Na podstawie tego czasu obliczana jest odległość od obiektu. Przykład dalmierza ręcznego:

Cechy urządzenia

- Zakres pomiaru od 0.05 do 200 m; dokładność ± 2 mm
- Power Range TechnologyTM
- Ergonomiczna konstrukcja z miękkim uchwytem
- Zintegrowana lunetka o dwukrotnym powiększeniu
- Rozkładana końcówka z automatycznym czujnikiem
- Pomiary pomieszczeń „za przyciśnięciem guzika"
- Pośrednie pomiary wysokości/odległości
- Norma IP54

Zalety

- Sprawne i dokładne w całym zakresie odległości
- Pozwala na dokonywanie pomiarów dużych odległości (ok. 100 m) bez użycia tarczy celowniczej
- Urządzenie leży przyjemnie w dłoni
- Nieocenione rozwiązanie przy pomiarze do odległych miejsc.
- Umożliwia bezproblemowe i stabilne pomiary od krawędzi lub narożników
- Sprawne wyznaczanie obwodu pomieszczenia lub powierzchni ścian i sufitów
- Pomiary w niedostępnych miejscach
- Odporność na deszcz i zapylenie – nieocenione na budowach.

DALMIERZ LASEROWY TLM 100 i

- Zasięg: 0.1 m do 30 m
- Dokładność pomiaru: 3 mm

- Klasa lasera: II
- Dioda: 635 nm
- Przełącznik pomiarów: od czoła lub od podstawy
- Dwuczęściowy wyświetlacz – 2 linie
- Funkcje: pomiar odległości, pomiar ciągły, dodawanie, odejmowanie, powierzchnia, kubatura
- Gumowany uchwyt
- W zestawie: pokrowiec
- Zasilanie: 2 x AAA
- Temperatury pracy: 0ºC – 40ºC
- Wymiary: 122 x 64 x 32 mm
- *(ang. laser measures - distance measurer)*

A long range laser rangefinder LRB20000 is capable of measuring distance up to 20 km; mounted on a tripod with an angular mount. The resulting system also provides azimuth and elevation measurements.

The laser chosen operates at 671 nm, which is right in the middle of the eye's most sensitive frequency range. This in contrast to an infrared laser or other frequency laser causes a physiological response from the viewer. (blink). Combined with the choice of a low power device these two decisions afford significant safety benefits. An additional benefit in using visible light is its extreme help in system troubleshooting/debugging.

Image:1.1

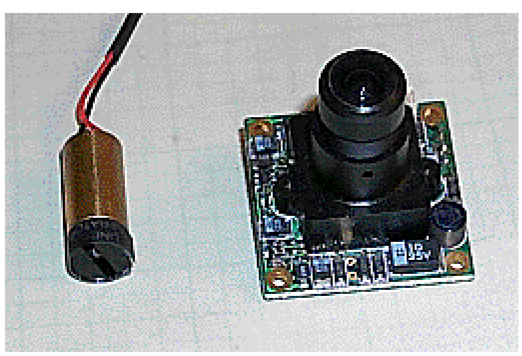


Diagram:1.1 http://www.seattlerobotics.org/encoder/200110/vision.htm

An overview, Diagram:1.1 shows how the laser is mounted on a mobile robot, 1/2" above and parallel to the floor. The Camera is mounted 5" up with a downward angle of 22.5

degrees. As well see in diagram:1.4 the swept angle of the camera is 48deg. These two (camera & laser) can be identified in diagram:1.1 as the two black objects on the right side of the image. The backdrop grid lines (gray on white) that make up the walls and floor in this scenario are on 1" centers. In later orthographic projections the reader can take advantage of this fact to read system metrics directly from the diagram.

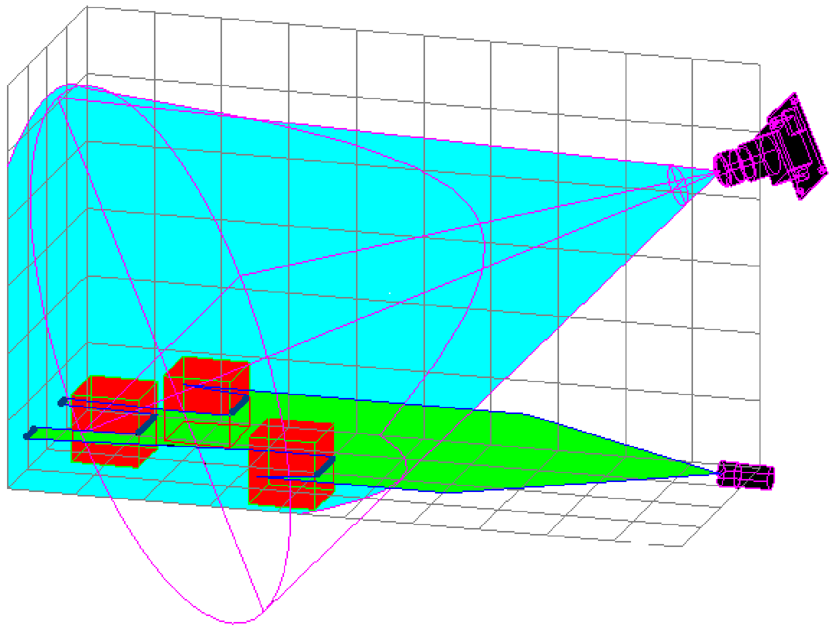


Diagram:1.2

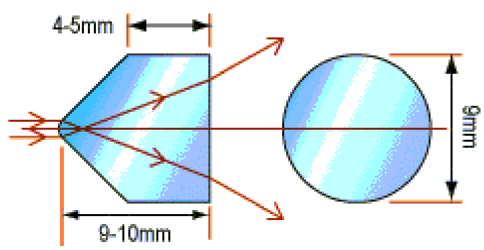
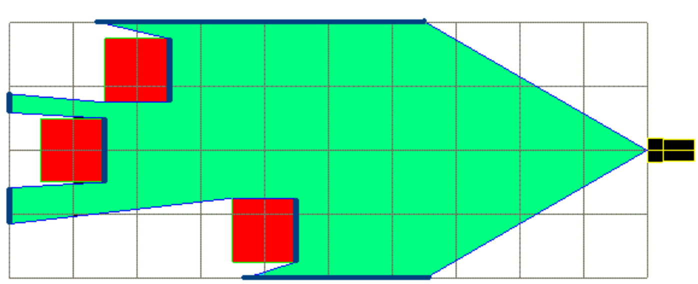
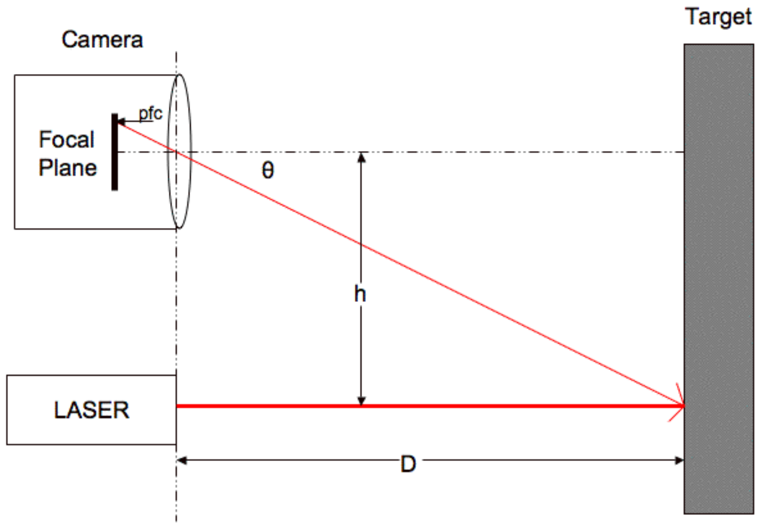


Diagram:1.3





A laser-beam is projected onto an object in the field of view of a camera. This laser beam is ideally parallel to the optical axis of the camera. The dot from the laser is captured along with the rest of the scene by the camera. A simple algorithm is run over the image looking for the brightest pixels. Assuming that the laser is the brightest area of the scene (which seems to be true for my dollar store laser pointer indoors), the dots position in the image frame is known. Then we need to calculate the range to the object based on where along the y axis of the image this laser dot falls. The closer to the center of the image, the farther away the object is.
http://www.pages.drexel.edu/~twd25/webcam_laser_ranger.html

distance (D) may be calculated:

$$D = \frac{h}{\tan\theta}$$

$$\theta = pfc * rpc + ro$$

Where:

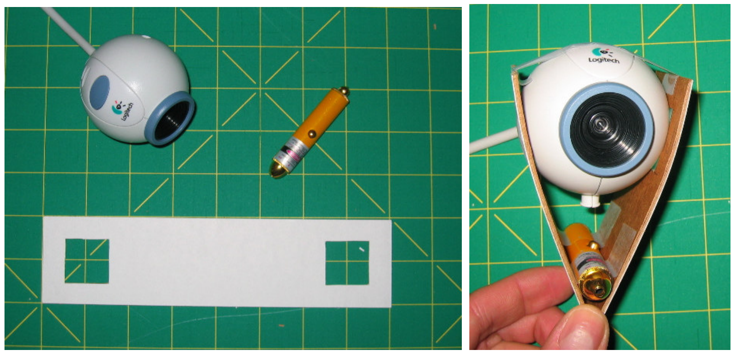
pfc = Number of Pixels From Center of Focal Plane

rpc = Radians per pixel pitch

ro = Radian offset (compensates for allignment errors)

Put the two above equations together, we get:

$$D = \frac{h}{\tan(pfc * rpc + ro)}$$



Range finder using webcamera

1.2. Technologies

Time of flight - this measures the time taken for a light pulse to travel to the target and back. With the speed of light known, and an accurate measurement of the time taken, the distance can be calculated. Many pulses are fired sequentially and the average response is most commonly used. This technique requires very accurate sub-nanosecond timing circuitry.

Multiple frequency phase-shift - this measures the phase shift of multiple frequencies on reflection then solves some simultaneous equations to give a final measure.

Interferometry - the most accurate and most useful technique for measuring changes in distance rather than absolute distances.

1.3. Applications

Military

An American soldier with the GVS-5 laser rangefinder.

Rangefinders provide an exact distance to targets located beyond the distance of point-blank shooting to snipers and artillery. They can also be used for military reconciliation and engineering.

Handheld military rangefinders operate at ranges of 2 km up to 25 km and are combined with binoculars or monoculars. When the rangefinder is equipped with a compass and inclinometer it is capable of providing magnetic azimuth, inclination, and height(length) of targets. Some rangefinders can also measure a target's speed in relation to the observer. Some rangefinders have cable or wireless interfaces to enable them to transfer their measurement(s) data to other equipment like fire control computers. Some models also offer the possibility to use add-on night vision modules. Handheld rangefinders use standard or non-magnetic batteries.

The more powerful models of rangefinders measure distance up to 25 km and are normally installed either on a tripod or directly on a vehicle or gun platform. In the latter case rangefinder module is integrated with on-board thermal, night vision and daytime observation equipment. The most advanced military rangefinders can be integrated with computer.

In order to make laser rangefinders and laser-guided weapons less useful against military targets, various military arms may have developed laser-absorbing paint for their vehicles. Regardless, some objects don't reflect laser light very well and using a laser rangefinder on them is difficult.

3-D Modelling

This lidar scanner may be used to scan buildings, rock formations, etc., to produce a 3D model. The lidar can aim its laser beam in a wide range: its head rotates horizontally, a mirror flips vertically. The laser beam is used to measure the distance to the first object on its path.

Laser rangefinders are used extensively in 3-D object recognition, 3-D object modelling, and a wide variety of computer vision related fields. This technology constitutes the heart of the so-called *time-of-flight* 3D scanners. In contrast to the military instruments described above, laser rangefinders offer high-precision scanning abilities, with either single-face or 360-degree scanning modes.

A number of algorithms have been developed to merge the range data retrieved from multiple angles of a single object in order to produce complete 3-D models with as little error as possible. One of the advantages that laser rangefinders offer over other methods of computer vision is that the computer does not need to correlate features from two images to determine depth information as in stereoscopic methods.

The laser rangefinders used in computer vision applications often have depth resolutions of tenths of millimeters or less. This can be achieved by using triangulation or refraction measurement techniques as opposed to the time of flight techniques used in LIDAR.

Handheld distance meters

Opti-Logic Corporation introduced the first consumer level time of flight handheld laser distance meter in 1987. The original handheld consumer priced laser rangefinders were used for golf. Since that time numerous applications have developed. The most popular use is for hunting.

Until 1993, phase shift instruments were reserved to professional users giving their prices and rich functions like bluetooth measurements transmission. Less expensive models around 150$/€ are emerging from Bosch with the DLE 50 or Stanley Works with the TLM 100.

Sports

Laser rangefinders may be effectively used in various sports that require precision distance measurement, such as golfing, hunting, archery, sniper shooting. Several manufacturers, such as Opti-logic Corporation, Bushnell, Leica, Nikon and Swarovski supply handheld rangefinders at prices well in line with the rest of sports equipment.

Handheld rangefinders are marked in terms of distance they measure to a reflective target, called rated distance. As a rule of thumb, rated distance should be divided by three to estimate actual average distance to a shooting target or golf pin. Practically speaking, a rangefinder marked as XYZ-1000 will give consistent measurements up to 400 m.

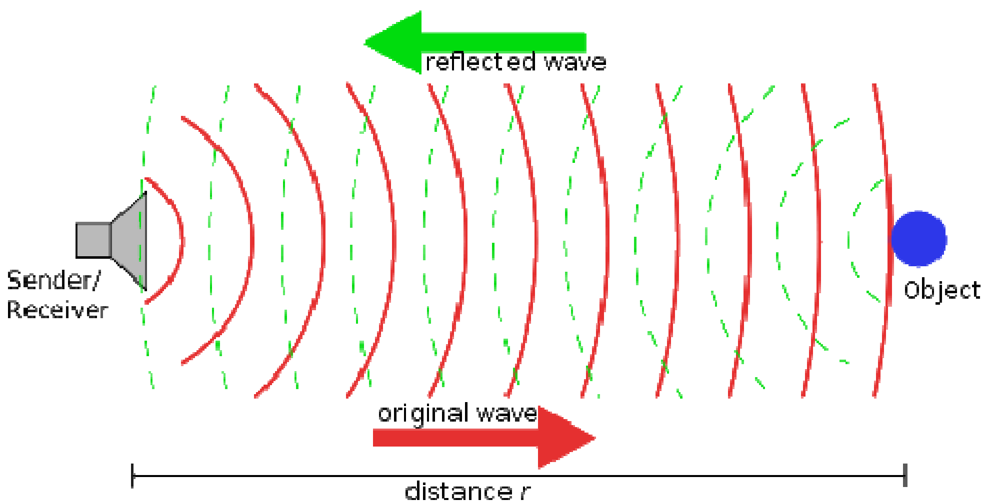
Industry production processes

An important application is the use of laser Range finder technology during the automation of stock management systems and production processes in steel industry.

1.4. Dalmierz ultradźwiękowy

An **Ultrasonic ranging module**, also called a range finder, is a small device that sends out a ultrasonic sound via a transducer, and since the sound has a very high frequency, a frequency that we can not hear, it bounces off objects pretty easily. Its main job is just to record the time it takes for the sound to bounce back and into the transducer. Then a controller will do the mathematics to determine the distance between the module and an object. there is a down side to some range finders, in robotics, it only can measure up to a few inches....

Sonar (originally an acronym for **sound navigation and ranging**) is a technique that uses sound propagation (usually underwater) to navigate, communicate with or detect other vessels. There are two kinds of sonar: active and passive. Sonar may be used as a means of acoustic location. Acoustic location in air was used before the introduction of radar. Sonar may also be used in air for robot navigation, and SODAR (an upward looking in-air sonar) is used for atmospheric investigations. The term *sonar* is also used for the equipment used to generate and receive the sound. The frequencies used in sonar systems vary from infrasonic to ultrasonic. The study of underwater sound is known as underwater acoustics or sometimes hydroacoustics.



Active sonar uses a sound transmitter and a receiver. When the two are in the same place it is monostatic operation. When the transmitter and receiver are separated it is bistatic operation. When more transmitters (or more receivers) are used, again spatially separated, it is multistatic operation. Most sonars are used monostatically with the same array often being used for transmission and reception, though when the platform is moving it may be necessary to consider a single transmitter/receiver as being operated bistatically. Active sonobuoy fields may be operated multistatically.

Active sonar creates a pulse of sound, often called a "ping", and then listens for reflections (echo) of the pulse. This pulse of sound is generally created electronically using a Sonar Projector consisting of a signal generator, power amplifier and electroacoustic transducer/array, possibly with a beamformer. However, it may be created by other means, e.g. chemically using explosives or by using heat sources in thermoacoustics.

French F70 type frigates (here, *La Motte-Picquet*) are fitted with VDS (Variable Depth Sonar) type DUBV43 or DUBV43C towed sonars; handheld sonar

Fish finder sonar

To measure the distance to an object, the time from transmission of a pulse to reception is measured and converted into a range by knowing the speed of sound. To measure the bearing, several hydrophones are used, and the set measures the relative arrival time to each, or with an array of hydrophones, by measuring the relative amplitude in beams formed through a process called beamforming. Use of an array reduces the spatial response so that to provide wide cover multibeam systems are used. The target signal (if present) together with noise is then passed through various forms of signal processing, which for simple sonars may be just energy measurement. It is then presented to some form of decision device that calls the output either the required signal or noise. This decision device may be an operator with headphones or a display, or in more sophisticated sonars this function may be carried out by software. Further processes may be carried out to classify the target and localise it, as well as measuring its velocity.

The pulse may be at constant frequency or a chirp of changing frequency (to allow pulse compression on reception). Simple sonars generally use the former with a filter wide enough to cover possible Doppler changes due to target movement, while more complex ones generally include the latter technique. Today, pulse compression is usually achieved using digital correlation techniques. Military sonars often have multiple beams to provide all-round cover while simple ones only cover a narrow arc. Originally the latter was often scanned around mechanically but this was a slow process.

Particularly when single frequency transmissions are used, the Doppler effect may be used to measure the radial speed of a target. The difference in frequency between the transmitted and received signal is measured and converted into a velocity. Since Doppler shifts can be introduced by either receiver or target motion, allowance has to be made for the radial speed of the searching platform.

Passive sonar listens without transmitting. It is often employed in military settings, although it is also used in science applications, e.g. detecting fish for presence/absence studies in various aquatic environments - see also passive acoustics and passive radar. In the very broadest usage, this term can encompass virtually any analytical technique involving remotely generated sound, though it is usually restricted to techniques applied in an aquatic environment.

Ship velocity measurement

Sonars have been developed for measuring a ship's velocity either relative to the water or to the bottom.

ROV and UUV

Small sonars have been fitted to Remotely Operated Vehicles (ROV) and Unmanned Underwater Vehicles (UUV) to allow their operation in murky conditions. These sonars are used for looking ahead of the vehicle. The Long-Term Mine Reconnaissance System is an UUV for MCM purposes.

Vehicle location

Sonars which act as beacons are fitted to aircraft to allow their location in the event of a crash in the sea. Short and Long Baseline sonars may be used for caring out the location, such as LBL.

Biomass estimation

Biomass estimation uses sonar to detect fish, etc. As the sound pulse travels through water it encounters objects that are of different density than the surrounding medium, such as fish, that reflect sound back toward the sound source. These echoes provide information on fish size, location, and abundance. See Also: Hydroacoustics

Wave measurement

An upward looking echo sounder mounted on the bottom or on a platform may be used to make measurements of wave height and period. From this statistics of the surface conditions at a location can be derived.

Water velocity measurement

Special short range sonars have been developed to allow measurements of water velocity.

Bottom type assessment

Sonars have been developed that can be used to characterise the sea bottom into, for example, mud, sand, and gravel. Relatively simple sonars such as echo sounders can be promoted to seafloor classification systems via add-on modules, converting echo parameters into sediment type. Different algorithms exist, but they are all based on changes in the energy or shape of the reflected sounder pings. Advanced substrate classification analysis can be achieved using calibrated (scientific) echosounders and parametric or fuzzy-logic analysis of the acoustic data (See: Acoustic Seabed Classification)

Bottom topography measurement

Side-scan sonars can be used to derive maps of the topography of an area by moving the sonar across it just above the bottom. Low frequency sonars such as GLORIA have been used for continental shelf wide surveys while high frequency sonars are used for more detailed surveys of smaller areas.

Sub-bottom profiling

Powerful low frequency echo-sounders have been developed for providing profiles of the upper layers of the ocean bottom.

Synthetic aperture sonar

Various synthetic aperture sonars have been built in the laboratory and some have entered use in mine-hunting and search systems. An explanation of their operation is given in synthetic aperture sonar.

Parametric sonar

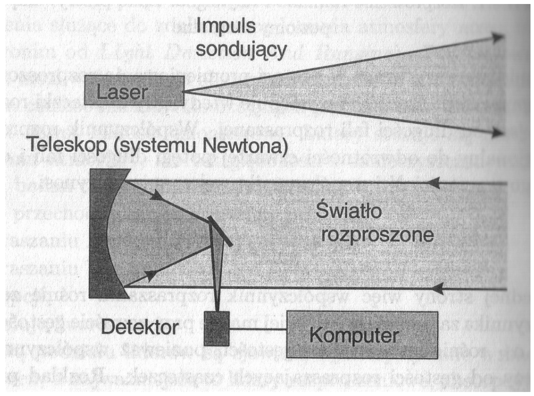
Parametric sources use the non-linearity of water to generate the difference frequency between two high frequencies. A virtual end-fire array is formed. Such a projector has advantages of broad bandwidth, narrow beamwidth, and when fully developed and carefully measured it has no obvious sidelobes: see Parametric array. Its major disadvantage is very low efficiency of only a few percent. P.J. Westervelt's seminal (and brief!) 1963 JASA paper summarizes the trends involved. In theory, a parametric receiver is possible but there is no known implementation.

1.5. LIDAR (**Li**ght **D**etection **a**nd **R**anging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. This lidar (laser range finder) may be used to scan buildings, rock formations, etc., to produce a 3D model. LIDAR technology has application in archaeology, geography, geology, geomorphology, seismology, remote sensing and atmospheric physics. The primary difference between lidar and radar is that with lidar, much shorter wavelengths of the electromagnetic spectrum are used, typically in the ultraviolet, visible, or near infrared. In general it is possible to image a feature or object only about the same size as the wavelength, or larger. Thus lidar is highly sensitive to aerosols and cloud particles and has many applications in atmospheric research and meteorology. An object needs to produce a dielectric discontinuity in order to reflect the transmitted wave. At radar (microwave or radio) frequencies, a metallic object produces a significant reflection. However non-metallic objects, such as rain and rocks produce weaker reflections and some materials may produce no detectable reflection at all, meaning some objects or features are effectively invisible at radar frequencies.

The lidar can aim its laser beam in a wide range: its head rotates horizontally, a miror flips vertically. The laser beam is used to measure the distance to the first object on its path.

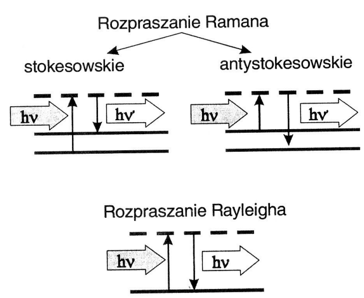
Model: Leica HDS-3000

Maximum 360° x 270° field-of-view
Unique dual-window design
Fully selectable field-of-view and scan density
Bore-sighted digital camera for automatically calibrated photo overlays
<6 mm spot size @ 50 m
6 mm positional accuracy @ 50 m
Height-of-instrument (H.I.) measurement
Setup over survey point
Flexible "hot-swap" power supply system
QuickScan™ button



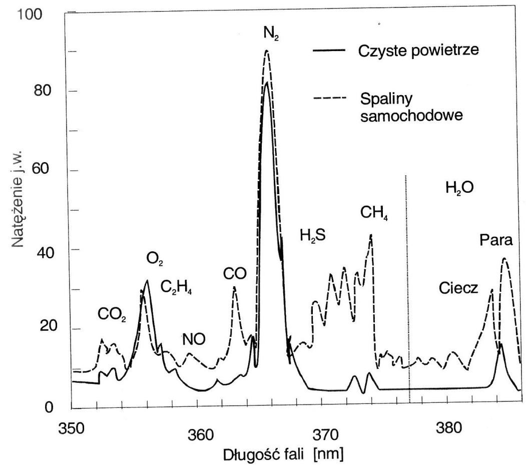
This is especially true for very small objects (such as single molecules and aerosols). Lasers provide one solution to these problems. The beam densities and coherency are excellent. Moreover the wavelengths are much smaller than can be achieved with radio systems, and range from about 10 micrometers to the UV (ca. 250 nm). At such wavelengths, the waves are "reflected" very well from small objects. This type of reflection is called backscattering. Different types of scattering are used for different lidar applications, most common are Rayleigh scattering, Mie scattering and Raman scattering as well as fluorescence.

Rozpraszanie Rayleigh'a (cząsteczki rozpraszające mniejsze od długości fali rozpraszanej), **Mie** (cząsteczki większe od długości fali rozproszonej, światło odbite od różnych fragmentów cząstki może interferować) – bez zmiany długości światła rozpraszanego, **Ramana** – nieelastyczne przekazanie energii między fotonem i cząsteczką



Światło sondujące wysyłane przez laser w postaci impulsów (~mJ, ~ns, ~Hz), światło rozpraszane odbierane przez teleskop. Analiza sygnału: równanie lidaru pozwalające wyznaczyć żądaną charakterystykę z natężenia lub długości fali światła docierającego do detektora – pomiar rozmiaru zanieczyszczeń, koncentracji i prędkości.

W liderach Ramana – obserwacja przesunięcia linii światła rozproszonego względem pierwotnej. Pozwala to zidentyfikować zanieczyszczenia:



Wzbudzenie laserem azotowym 337 nm

Przy pomocy liderów absorpcyjnych – lasery barwnikowe – bada się absorpcje światła przez cząsteczki zanieczyszczające atmosferę (absorpcja różnicowa – lidary Dial).

W lidarach fluorescencyjnych mierzy się widmo i natężenie fluorescencji wywołanej wiązką laserową (lasery barwnikowe).

Lidary dopplerowskie – przemieszczanie się cząstek atmosfery i turbulencji.

Badanie wód – lasery He-Cd i argonowe, azotowe, barwnikowe, ekscymerowe (najmniejsza absorpcja w obszarze niebiesko-zielonym).

Badania meteorologiczne – widzialność, morfologia obłoków, pułap i ewolucja chmur, gęstość i temperatura, prędkość wiatru.

The wavelengths are ideal for making measurements of smoke and other airborne particles (aerosols), clouds, and air molecules. A laser typically has a very narrow beam which allows the mapping of physical features with very high resolution compared with radar. In addition, many chemical compounds interact more strongly at visible wavelengths than at microwaves, resulting in a stronger image of these materials. Suitable combinations of lasers can allow for remote mapping of atmospheric contents by looking for wavelength-dependent changes in the intensity of the returned signal.

In general there are two types of lidar systems: **micropulse lidar** systems and **high energy** systems. Micropulse systems have developed as a result of the ever increasing amount of computer power available combined with advances in laser technology. They use considerably less energy in the laser, typically on the order of one microjoule, and are often "eye-safe," meaning they can be used without safety precautions. High-power systems are common in atmospheric research, where they are widely used for measuring many atmospheric parameters: the height, layering and densities of clouds, cloud particle properties (extinction coefficient, backscatter coefficient, depolarization), temperature, pressure, wind, humidity, trace gas concentration (ozone, methane, nitrous oxide, etc.

There are several major components to a lidar system:

1. **Laser** — 600-1000 nm lasers are most common for non-scientific applications. They are inexpensive but since they can be focused and easily absorbed by the eye the maximum power is limited by the need to make them eye-safe. Eye-safety is often a requirement for most applications. A common alternative 1550 nm lasers are eye-safe at much higher power levels since this wavelength is not focused by the eye, but the detector technology is less advanced and so these wavelengths are generally used at longer ranges and lower accuracies. They are also used for military applications as 1550 nm is not visible in night vision goggles unlike the shorter 1000 nm infrared laser. Airborne topographic mapping lidars generally use 1064 nm diode pumped YAG lasers, while bathymetric systems generally use 532 nm frequency doubled diode pumped YAG lasers because 532 nm penetrates water with much much less attenuation than does 1064 nm. Laser settings include the laser repetition rate (which controls the data collection speed). Pulse length is generally an attribute of the laser cavity length, the number of passes required through the gain material (YAG, YLF, etc.), and Q-switch speed. Better target resolution is achieved with shorter pulses, provided the Lidar receiver detectors and electronics have sufficient bandwidth[1].
2. **Scanner and optics** — How fast images can be developed is also affected by the speed at which it can be scanned into the system. There are several options to scan the azimuth and elevation, including dual oscillating plane mirrors, a combination with a polygon mirror, a dual axis scanner. Optic choices affect the angular resolution and range that can be detected. A hole mirror or a beam splitter are options to collect a return signal.
3. **Receiver and receiver electronics** — Receivers are made out of several materials. Two common ones are Si and InGaAs. They are made in either PIN diode or Avalanche photodiode configurations. The sensitivity of the receiver is another parameter that has to be balanced in a LIDAR design.
4. **Position and navigation systems** — Lidar sensors that are mounted on mobile platforms such as airplanes or satellites require instrumentation to determine the absolute position and orientation of the sensor. Such devices generally include a Global Positioning System receiver and an Inertial Measurement Unit (IMU).

Geology and Meteorology

In geology and seismology a combination of aircraft-based LIDAR and GPS have evolved into an important tool for detecting faults and measuring uplift. The output of the two technologies can produce extremely accurate elevation models for terrain that can even measure ground elevation through trees. This combination was used most famously to find the location of the Seattle Fault in Washington, USA. This combination is also being used to measure uplift at Mt. St. Helens by using data from before and after the

2004 uplift. Airborne LIDAR systems monitor glaciers and have the ability to detect subtle amounts of growth or decline. A satellite based system is NASA's ICESat which includes a LIDAR system for this purpose. NASA's Airborne Topographic Mapper is also used extensively to monitor glaciers and perform coastal change analysis.

LIDAR may also be used to measure the speed of atmospheric winds. Doppler LIDAR systems developed by NASA measure atmospheric wind speed along a line. Scanning LIDAR, such as NASA's HALIE LIDAR, have been used to measure atmospheric wind velocity in a large three dimensional cone. Applications extend to hurricane monitoring. ESA's wind mission ADM-Aeolus will be equipped with a doppler LIDAR system in order to provide global measurements of vertical wind profiles. A doppler LIDAR system was used in the 2008 Summer Olympics. The pulse laser can measure the range of the object. Doppler LIDAR systems are also now beginning to be successfully applied in the renewable energy sector to acquire wind speed, turbulence, wind veer and wind shear data. Both pulsed and continuous wave systems are being used. Pulsed systems using signal timing to obtain vertical distance resolution, whereas continuous wave systems rely on detector focussing.

Physics and Astronomy

A world-wide network of observatories uses lidars to measure the distance to reflectors placed on the moon, allowing the moon's position to be measured with mm precision and tests of general relativity to be done. MOLA, the Mars Orbiting Laser Altimeter, used a LIDAR instrument in a Mars-orbiting satellite (the NASA Mars Global Surveyor) to produce a spectacularly precise global topographic survey of the red planet.

In September, 2008, NASA's Phoenix Lander used LIDAR to detect snow in the atmosphere of Mars.

In atmospheric physics, LIDAR is used as a remote detection instrument to measure densities of certain constituents of the middle and upper atmosphere, such as potassium, sodium, or molecular nitrogen and oxygen. These measurements can be used to calculate temperatures. LIDAR can also be used to measure wind speed and to provide information about vertical distribution of the aerosol particles.

At the JET nuclear fusion research facility, in the UK near Abingdon, Oxfordshire, LIDAR Thomson Scattering is used to determine Electron Density and Temperature profiles of the plasma.[10]

Biology and conservation

LIDAR has also found many applications in forestry. Canopy heights, biomass measurements, and leaf area can all be studied using airborne LIDAR systems. Similarly, LIDAR is also used by many industries, including Energy and Railroad, and the Department of Transportation as a faster way of surveying. Topographic maps can also be generated readily from LIDAR, including for recreational use such as in the production of orienteering maps.

In oceanography, lidars are used for estimation of phytoplankton fluorescence and generally biomass in the surface layers of the ocean. Another application is airborne lidar bathymetry of sea areas too shallow for hydrographic vessels. Much of this research has been conducted at the Center for Coastal and Ocean Mapping Joint Hydrographic Center by Dr. Shachak Pe'eri and Captain Armstrong.

Military and law enforcement

One situation where LIDAR has notable non-scientific application is in traffic speed law enforcement, for vehicle speed measurement, as a technology alternative to radar guns. The technology for this application is small enough to be mounted in a hand held camera "gun" and permits a particular vehicle's speed to be determined from a stream of traffic. Unlike RADAR which relies on doppler shifts to directly *measure* speed, police lidar relies on the principle of time-of-flight to calculate speed. The equivalent radar based systems are often not able to isolate particular vehicles from the traffic stream and are generally too large to be hand held. LIDAR has the distinct advantage of being able to pick out one vehicle in a cluttered traffic situation as long as the operator is aware of the limitations imposed by the range and beam divergence. Contrary to popular belief LIDAR does not suffer from “sweep” error when the operator uses the equipment correctly and when the LIDAR unit is equipped with algorithms that are able to detect when this has occurred. A combination of signal strength monitoring, receive gate timing, target position prediction and pre-filtering of the received signal wavelength prevents this from occurring. Should the beam illuminate sections of the vehicle with different reflectivity or the aspect of the vehicle changes during measurement that causes the received signal strength to be changed then the LIDAR unit will reject the measurement thereby producing speed readings of high integrity. For LIDAR units to be used in law enforcement applications a rigorous approval procedure is usually completed before deployment. Jelly-bean shaped vehicles are usually equipped with a vertical registration plate that, when illuminated causes a high integrity reflection to be returned to the LIDAR, many reflections and an averaging technique in the speed measurement process increase the integrity of the speed reading. In locations that do not require that a front or rear registration plate is fitted headlamps and rear-reflectors provide an almost ideal retro-reflective surface overcoming the reflections from uneven or non-compliant reflective surfaces thereby eliminating “sweep” error. It is these mechanisms which cause concern that LIDAR is somehow unreliable. Most traffic LIDAR systems send out a stream of approximately 100 pulses over the span of three-tenths of a second. A "black box," proprietary statistical algorithm picks and chooses which progressively shorter reflections to retain from the pulses over the short fraction of a second.

Military applications are not yet known to be in place and are possibly classified, but a considerable amount of research is underway in their use for imaging. Their higher resolution makes them particularly good for collecting enough detail to identify targets, such as tanks. Here the name LADAR is more common.

Five LIDAR units produced by the German company Sick AG were used for short range detection on Stanley, the autonomous car that won the 2005 DARPA Grand Challenge.

Vehicles

Lidar has been used to create Adaptive Cruise Control (ACC) systems for automobiles. Systems such as those by Siemens and Hella use a lidar device mounted in the front of the vehicle to monitor the distance between the vehicle and any vehicle in front of it. In the event the vehicle in front slows down or is too close, the ACC applies the brakes to slow the vehicle. When the road ahead is clear, the ACC allows the vehicle to speed up to speed preset by the driver.

2. Laserowe naprowadzanie

Samonaprowadzanie pocisków - samoczynne kierowanie się pocisku na cel (samolot, okręt, rakieta), polegające na automatycznym wykrywaniu celu, określaniu jego położenia i uruchamianiu układu sterującego powodującego spotkanie pocisku z celem albo wybuch pocisku w odległości zapewniającej zniszczenie celu. Samonaprowadzanie stosuje się najczęściej w pociskach rakietowych: lotniczych klasy powietrze - powietrze, powietrze - woda i przeciwlotniczych.

W zależności od miejsca znajdowania się pierwotnego źródła energii wykorzystywanego do pracy układu samonaprowadzania rozróżnia się:

samonaprowadzanie aktywne - polega na ciągłym opromienianiu celu falami elektromagnetycznymi przez nadajnik znajdujący się w pocisku i odbieraniu fal odbitych od celu przez układ odbiorczy znajdujący się również w pocisku.

samonaprowadzanie półaktywne - polega na ciągłym odbieraniu fal elektromagnetycznych odbitych od celu, lecz wysyłanych przez nadajnik znajdujący się poza pociskiem. Do samonaprowadzania półaktywnego można używać nadajnika wysyłającego promieniowanie radiowe, widzialne, promieniowanie podczerwone lub fale akustyczne.

samonaprowadzanie pasywne - stosuje się przy kierowaniu pocisków na obiekty, które są silnym źródłem promieniowania podczerwonego, świetlnego, radiowego lub źródłem drgań akustycznych. Odbiornik promieniowania znajduje się na pokładzie pocisku.

Laser guidance is a technique of guiding a missile or other projectile or vehicle to a target by means of a laser beam. Some laser guided systems utilise beam riding guidance, but most operate more similarly to semi-active radar homing (SARH). This technique is sometimes called **SALH**, for **Semi-Active Laser Homing**. With this technique, a laser is kept pointed at the target and the laser radiation bounces off the target and is scattered in all directions (this is known as "painting the target," or "laser painting"). The missile, bomb, etc. is launched or dropped somewhere near the target. When it is close enough that some of the reflected laser energy from the target reaches it, a laser seeker notices which direction this energy is coming from and aims the projectile towards the source. As long as the projectile is in the right general area and the laser is kept aimed at the target, the projectile should be guided accurately to the target.

Note that laser guidance isn't useful against targets that don't reflect much laser energy, including those coated in special paint which absorbs laser energy. This is likely to be widely used by advanced military vehicles in order to make it harder to use laser rangefinders against them and harder to hit them with laser-guided munitions.

2.1. Semi-active radar homing, or **SARH**, is a common type of missile guidance system, perhaps the most common type for longer range air-to-air and surface-to-air missile systems. The name refers to the fact that the missile itself is only a passive detector of a radar signal – provided by an external ("offboard") source – as it reflects off the target.

NATO brevity code for a semi-active radar homing missile launch is **Fox One**.

The basic concept of SARH is that since almost all detection and tracking systems consist of a radar system, duplicating this hardware on the missile itself is a waste. In addition, the resolution of a radar is strongly related to the physical size of the antenna, and in the small nose cone of a missile there isn't enough room to provide the sort of accuracy needed for guidance. Instead the larger radar dish on the ground or launch aircraft will provide the needed signal and tracking logic, and the missile simply has to listen to the signal reflected from the target and point itself in the right direction. Additionally, the missile will listen rearward to the launch platform's transmitted signal as a reference, enabling it to avoid some kinds of radar jamming distractions offered by the target.

Contrast this with beam riding systems, in which the radar is pointed at the target and the missile keeps itself centered in the beam by listening to the signal at the rear of the missile body. In the SARH system the missile listens for the reflected signal at the nose, and is still responsible for providing some sort of "lead" guidance. The advantages are twofold. One is that a radar signal is "fan shaped", growing larger, and therefore less accurate, with distance. This means that the beam riding system is not terribly accurate at long ranges, while SARH is largely independent of range and grows more accurate as it approaches the target—the "source" of the signal it listens for. Another difference is that a beam riding system must accurately track the target at high speeds, typically requiring one radar for tracking and another "tighter" beam for guidance. The SARH system needs only one radar set to a wider pattern.

2.2. Active radar homing is a missile guidance method in which a guided missile contains a radar transceiver and the electronics necessary for it to find and track its target autonomously. NATO brevity code for active radar homing missile launch is **Fox Three**.

There are two major advantages to active radar homing:

- Because the missile is tracking the target, and the missile is typically going to be much closer to the target than the launching platform during the terminal phase, the tracking can be much more accurate and also have better resistance to ECM. Active radar homing missiles have some of the best kill probabillities, along with missiles employing track-via-missile guidance.
- Because the missile is totally autonomous during the terminal phase, the launch platform doesn't need to have its radar enabled at all during this phase, and in the case of a mobile launching platform like an aircraft, can actually exit the scene or undertake other actions while the missile homes in on its target. This is often referred to as fire-and-forget capability and is a great advantage that modern air-to-air missiles have over their predecessors.

Examples of missiles which use active radar homing (all in their terminal phase) include:

- Russian AA-X-13 'Arrow' (Vympel R-37)
- Russian AA-12 'Adder' (Vympel R-77)
- Russian SA-N-20 'Gargoyle' (P-400 'Triumf')
- Russian SS-N-12 'Sandbox' ASCM (P-500 'Bazalt')
- Russian SS-N-19 'Shipwreck' ASCM (P-700 'Granit')
- American AIM-120 AMRAAM
- American SM-6 Improved Standard
- American RGM-84 Harpoon (also AGM-84, UGM-84)
- European MBDA Meteor
- German AS.34 Kormoran
- French MICA
- American PAC-3
- American AGM-114L Hellfire Longbow

2.3. Infrared homing refers to a passive missile guidance system which uses the emission from a target of electromagnetic radiation in the infrared part of the spectrum to track it. Missiles which use infrared seeking are often referred to as "heat-seekers", since infrared (IR) is just below the visible spectrum of light in frequency and is radiated strongly by hot bodies. Many objects such as people, vehicle engines and aircraft generate and retain heat, and as such, are especially visible in the infra-red wavelengths of light compared to objects in the background.

The NATO brevity code for an air-to-air infrared-guided missile launch is **"Fox Two"**

A modern German Luftwaffe IRIS-T infrared homing air-to-air missile

The three main materials used in the infrared sensor are lead sulfide (PbS), Indium Antimonide (InSb) and MerCad telluride (HgCdTe). Older sensors tend to use PbS, newer sensors tend to use InSb or HgCdTe. All perform better when cooled, as they are both more sensitive and able to detect cooler objects.

Early infrared seekers were most effective in detecting infrared radiation with shorter wavelengths, such as the 4.2 micrometre emissions of the carbon dioxide efflux of a jet engine. Such seekers, which are most sensitive to the 3 to 5 micrometre range, are now called "**single-color**" seekers. Modern infrared seekers also operate in the 8 to 13 micrometre wavelength range, which is absorbed least by the atmosphere. Such seekers are called "**two-color**" systems. Two-color seekers are harder to defeat with countermeasures such as flares and jammers.