The lidar method contribution to information theory and a UAV concept utilizing it.

A BRIEF REVIEW ON THE HISTORY OF LIDAR TECHNOLOGY

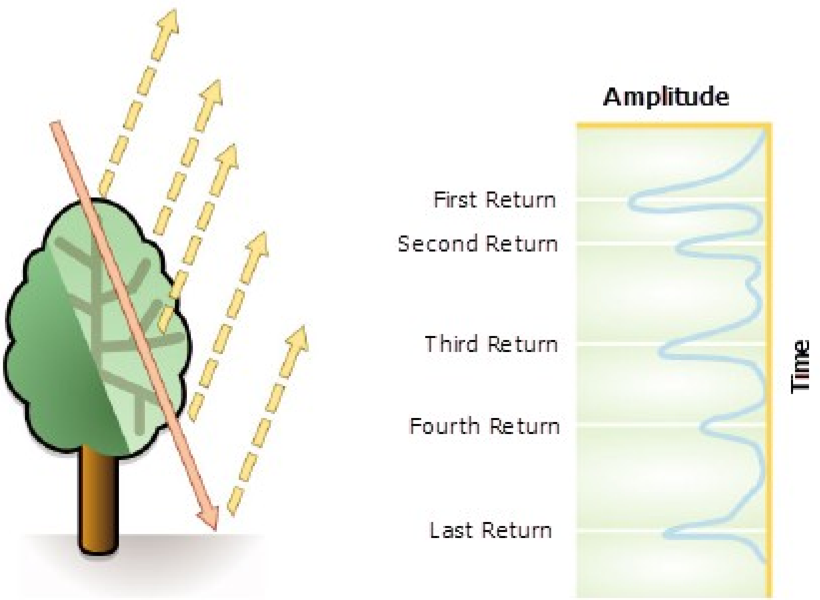
The name LIDAR preexisted because other basic optic techniques that were using lamp, as a mean for obtaining one handstand allocation, preexisted and started at the ’30 decade by Sygne (1930), Hullbert (1937), Johnson (1939) and Elterman (1954), who used carbon arc lamps and then Friedland (1956) who used pulsing light. During that period, the scientists gained enough information about the height of the atmosphere scanning the visual field of a distant telescope alongside a constant light radiation. In 1938 for the first time light pulses were used to measure the basic clouds’ height. The generation, using a layout of distant pulses, the beam emission and the receiver –telescope , was substituted by the scientists’ generation that used the transmitter and the receiver placed with a specific way so that the height information can be generated by the time measurement between the transmitting pulse and scouts signal and backwards. These specific lidar (acronym lidar) which were used in these measurement techniques were evolved by Middleton and Spilahaus (1953). In 1960 began the evolution of the new technology lidar because of the invention of laser and pulse, namely “Q-switched laser (1962). Afterwards, Fiocco and Smullin (1963) published icons of the atmosphere using the ruby laser. During a decade all the basic laser techniques have already been formed. From this time period, the lidars have met a huge success which is connected with a progress of laser technology. The most layouts that were designed using laser were designed mostly for lidar in order to satisfy the huge demands of certain techniques concerning the laser power, wavelength, width of pulse, spectral classification clarity and the shape form fascicle. As concerns the atmosphere, after the evolution of the laser and the light-scouters, many lidar system types were used repeatedly to study the atmosphere of the earth and to scout the different types of air pollutants and also 46 molecular pollutants, like O3, NOx, SO2, Hg, benzene (Koelsch et al, 1989), and measure the optical qualities of the air pollutants, like the optic depth and the backscatter and attenuation contributors. Concerning the laser and the light-scouters, many researches took place in 1992, in 2003 by Boesenberg and others and in 2004 by Kovalev and Eichinger. The foundation of the European Aerolosl Lidar Network (EARLINET) in 2000, based on Boesenberg’s research, let the foundation of a three - year climatology over the handstand allocation of the air pollutants, mainly in central Europe, Greece, Poland and Belarus. From the EARLINET’s beginning, 20.000 handstand allocations of air pollutants were collected under various meteorological circumstances, concerning the local and the big scale transfer of the air pollutants to the troposphere, including the transfer of dust coming from Sahara Desert, which spreads to the atmosphere of Europe and from the volcano Etna of the West Coast of Sicily in 2005 and the volcano Eyjafjallajökull of Island in 2010.

GENERAL DESCRIPTION OF OPERATION MODE AND LASER RADAR SYSTEM

Laser radar or laser 3D scanning, 1960s, for the detection of anti submarine aircraft and early model has been successfully used in the beginning of 1970s, the design in the United States, Canada and Australia. In the past ten years there has been a multiplication using a laser radar sensor, in the UK, there are a few to be used regularly in the air and the ground mark.

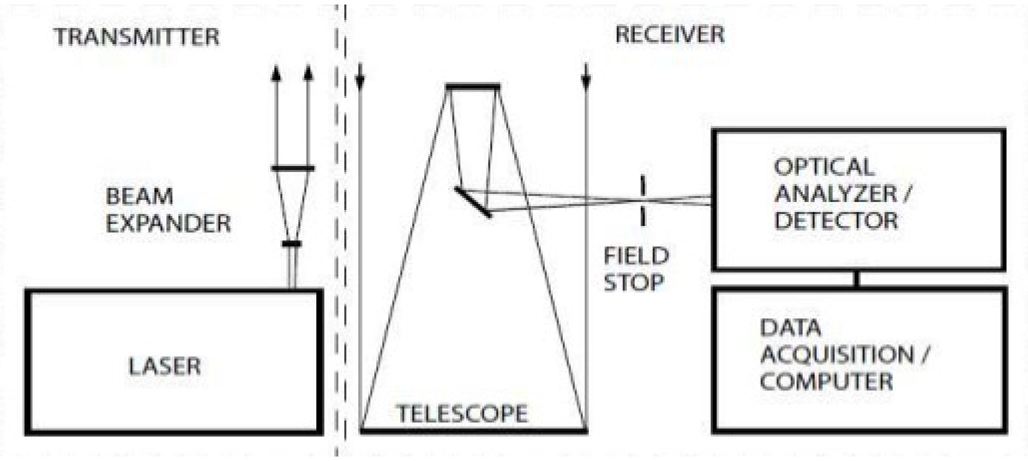
Most of the airborne laser radar sensors consist of a lidar, a GPS receiver, an inertial measurement unit (IMU), a travel, a computer and a device for storing data.

The laser radar system sends a pulsed laser beam to the reflector, which is presented in a downward aerial platform, usually a stationary blade of an aircraft or a helicopter. From the edge to the edge of the beam scanning and the aircraft flew over the area between the measurement study, 20 thousand to 150 thousand points per second.When the laser beam is reflected back in the mirror. The time interval between the pulses from the aerial platform and the sensor laser radar returns the measurement and recording. GPS accurately determine the location of the rotor with the longitude and elevation. Laser radar sensors collect large amounts of data and records can easily create a single point of storage in the record.



1. Red straight = signal from the plane
2. Yellow straight = many micro-signals, which have in the information ready for recording and editing, are directed back to the airplane tracking system.

The lidar technique, analyzing the backscattering signals that originate from the interaction of its components at the atmosphere by the laser radiation, is able to determine the vertical distribution of the main pollutants and constituents at the atmosphere with a high spatial (~ 3-7 m) and at the same time with a high spatial in timing (10-30 s).



Typical system layout Lidar(Weitkamp, 2005).

The main components that make up a device sensing LIDAR is a strong pulsed LASER source, an optical backscattering radiation detection system (telescope) and its conversion into electrical signal and a recording system, which captures and digitizes the signal. Finally, a computer is used for storing and processing of data obtained. A laser pulse power of some MW or TW is directed through mirrors into the atmosphere. Often, a small part of this pulse (approximately 1%) taken as a sample to determine the following: the principle of time measurement (definition of zero time t 0), the reference signal, which with the return signal can be normalized and pay a price for the energy output, due to the fact that the radiated energy of laser beam varies in time, and control of the wavelength of the laser in use case variable-wavelength laser.

HOW MANY TYPES OF LIDAR SYSTEM EXIST?

Over the last years various lidar techniques were developed about telescoping atmosphere parameters, which were based on different interactions of emitting radiation and various ingredients of the atmosphere that is under research. Thus there are lidar layouts that are based on the scatter of laser radiation by the atmospheric molecules (Rayleigh scatter), the scatter by the air pollutants (Mie scatter), the Raman scatter, the scatter coordination, fluorescence, absorption and the differential scatter/absorption from the atmosphere molecules. A sort description of the aforementioned optical interactions of the laser radiation, is further presented (Measures, 1988).

- Rayleigh Scatter: The laser flexibly scatters from atoms or molecules, without differentiation of the wavelength of the scattered radiation.
- Mie Scatter: The laser radiation flexibly scatters from small particles, without differentiation of the wavelength of the scattered radiation.

- Raman Scatter: The laser radiation scatters untirely from the molecules, with displacement of the wavelength of the scattered radiation.
- Scatter coordination: The frequency of the emitted laser radiation coincides with the frequency of a particular atom's energy transition, stimulated, and then scatters unroused, without offset in wavelength.
- Fluorescence: The frequency of the emitted laser radiation coincides with the frequency of a particular atom's energy transition, absorbed partially and then re-transmitted at a longer wavelength.
- Absorption : The beam of the laser radiation weakens due to convergence of the wavelength absorption band with such molecule
- Differential scatter/absorption: The differential attenuation of two laser beams, as shown by backscattering marks, when the frequency of a ray coincides with the frequency of known molecular transition, while the frequency of another is just after or before this characteristic frequency.

Depending on the physical mechanism that is used to place a measurement, lidar systems may be classified into several categories which we mention below (Weitkamp 2005):

• Lidar backscatter

• Absorption Lidar

• Lidar Raman

• Fluorescence Lidar

• Lidar Doppler

THE BASIC EQUATION EXPRESSING LIDAR

$P(R) = KG(R) * \beta(R)\ T(R)$

(i) P = POWER

(ii) R = DISTANCE

(iii) K = SYSTEM PERFORMANCE

(iv) G (R) = GEOMETRY OF MEASUREMENT

(v) β (R) = BACKSCATTERING FACTOR AT DISTANCE R

(vi) T (R) = MOUNT EMISSION THAT DESCRIBED HOW LIGHT DURING THE SENA ROUTE FROM AND TO THE LIDAR.

IN WHAT AREAS-VARIOUS FIELDS CAN BE USED THIS TECHNOLOGY:

-Forest Management and Planning Flood-modeling

-Modeling of Pollution

-Surveying and mapping

-Urban Design

-Coastal Management

-3d Street mapping

-Oil and gas Detection

-Archaeology

A very helpful video to understand what does this technology but at the same time and how, by Professor Nicholas Coops responsible research team, Chair in Remote Sensing, University of British Columbia.

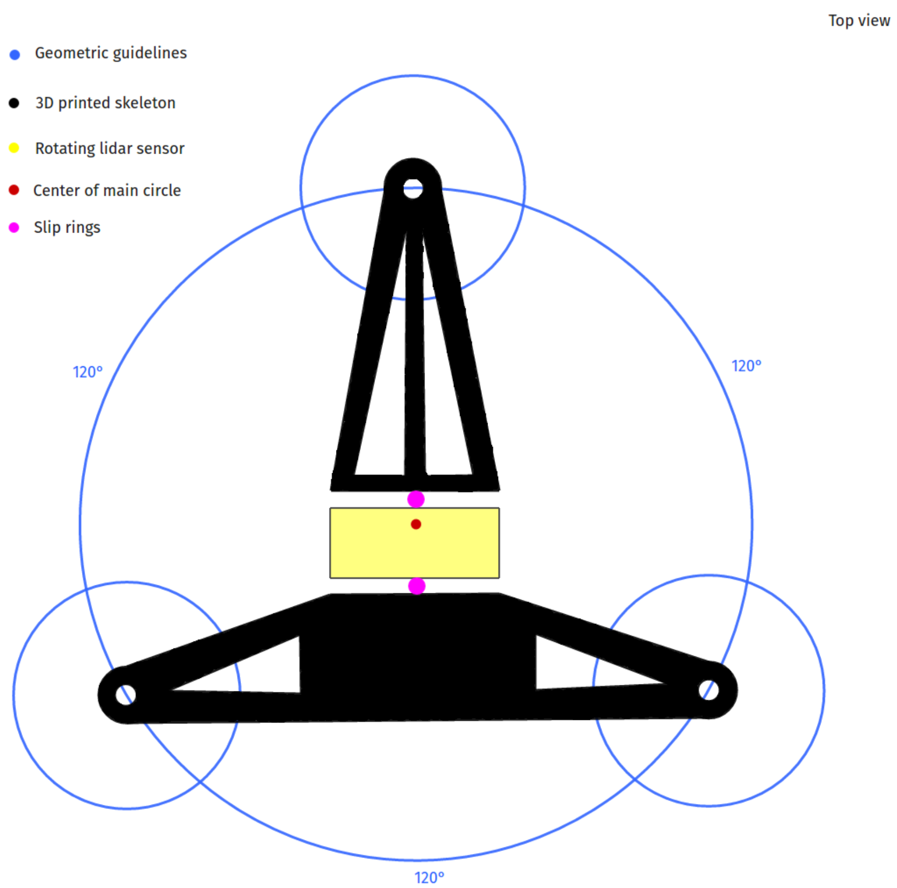
Link: https://www.youtube.com/watch?v=HfV7jJgrw4Q

The Prometheus UAV concept

This is a UAV concept inspired from the ones seen in the movie "Prometheus", designed to do the exact same thing. Simultaneous localization and mapping (S.L.A.M.). It can also detect life, like the ones in the movie, by heat signatures since thermal sensors can be added to it, if need be. A list with all of the parts needed to construct one can be found in the end.

A tricopter design was used due to the energy efficiency it provides compared to other UAVs with more motors, like quadcopters, while maintaining stability and agility. A helicopter designed could not be implemented since the rotors placement does not provide a way to cancel out the torque created by the rotating(roll axis) lidar sensor.

As illustrated bellow, the basic tricopter principle is followed resulting in all motors being equidistant. As a result, the center of gravity can be found in the middle of all three motors. We will alter that center of gravity by placing most of our components closer to the 2 front motors for a couple of reasons. The first reason being that when the rotating sensor is closer to those 2 front motors the torque its rotation produces is easier to cancel out. The second is that when the center of gravity is to the front, the motor positioned in the back which is mainly responsible for the "yaw" and "pitch" of the UAV has less weight distributed to it, resulting to faster maneuverability.



The UAV has 4 motors. 3 motors are used for the propellers. A tilt mechanism at the back motor in order to control the “yaw” of the UAV is also needed. The propellers for the 3 motors can differ in size, type, length etc., as long as they do not block the lidar's scanning field of view.

1 motor is used for the lidar sensor, which in order to capture data at a 360° radius, must be constantly rotating. This rotation will be around the “roll” axis of the UAV.

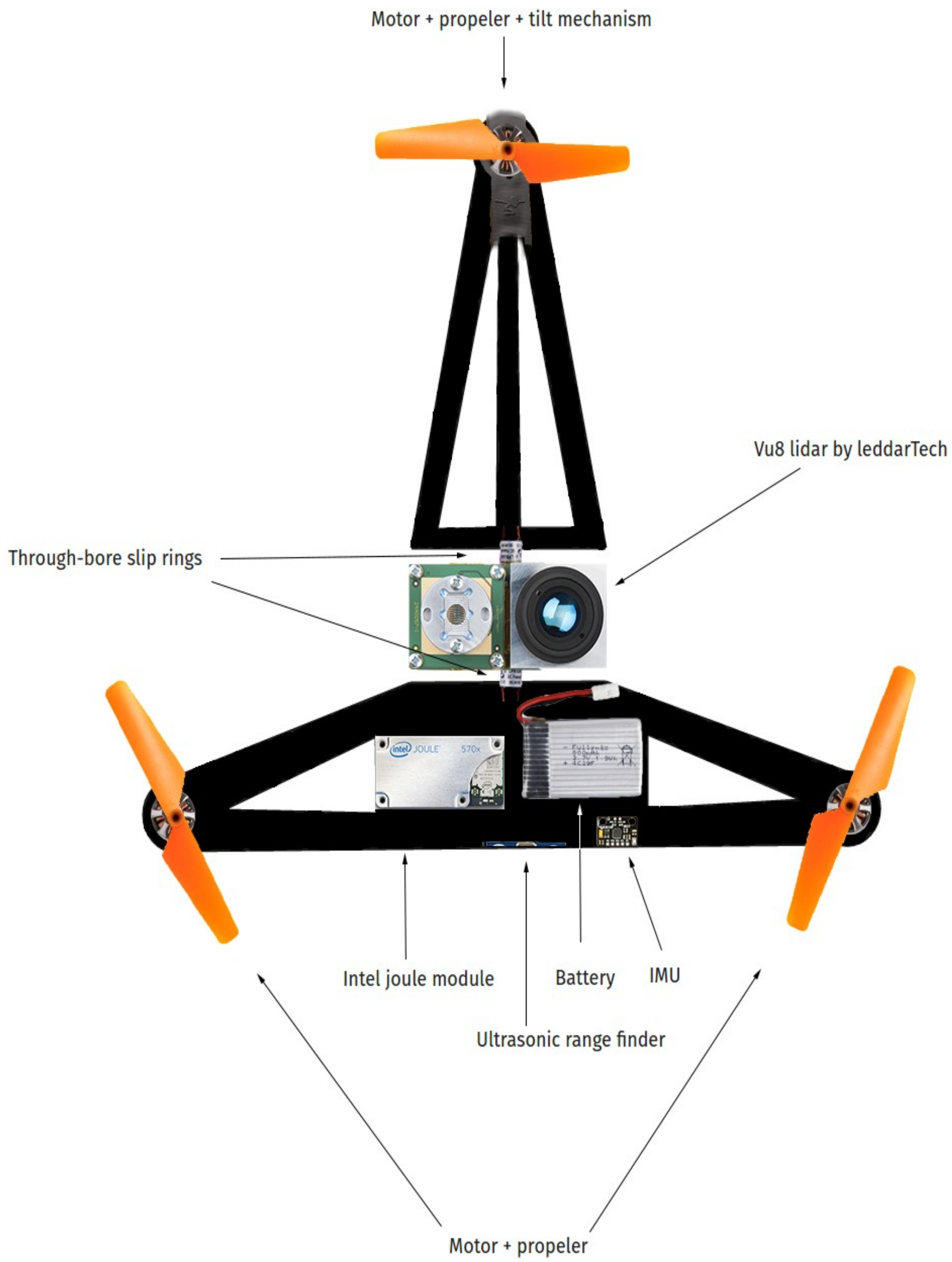
For that purpose 2 through-bore slip rings are used, in order for the front and the back parts of the 3d printed skeleton to be connected, resulting to one unibody skeleton (the front and back are not 2 separate parts), preventing further anomalies from the lidar rotation.

The lidar is not the only sensor on the UAV. Despite being very accurate, because of its placement, the UAV is not able to scan what is ahead of it. In order for the drone to proceed at a certain direction, that direction must have been previously scanned by the lidar. In some scenarios though, environments are dynamic. That is why an inexpensive ultrasonic range finder is placed in the front of the UAV, to prevent possible collisions.

In order for the software to fluctuate motor speeds and move the tilt mechanism in order to maintain balance and maneuver the UAV, an IMU unit is needed for the required input data, which is also placed in the front section of the UAV skeleton.

Finally, the brains of the UAV, a board module (the Intel joule module is illustrated bellow) is also placed at the front along with the battery to power everything that has been mentioned so far.

It must be noted that all the parts listed in the end are not to be taken accordingly. Depending on the maker's needs and budget, a variety of options differing in price, performance and size can be found as an alternative for every component.


Motor + propeler + tilt mechanism
Vu8 lidar by leddarTech
Through-bore slip rings
Intel joule module
Battery
IMU
Ultrasonic range finder
Motor + propeler

Equipment and parts needed for the “Prometheus” UAV concept

- Cheapest possible 3d printer + PLA cord
- Intel joule developer kit
- Vu8 (20° version) by leddarTech lidar sensor
- 2 through bore slip rings(1 with motor)
- IMU module
- Tilt mechanism
- Lipo battery
- Ultrasonic range finder module

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3) http://oceanservice.noaa.gov/facts/lidar.html

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