PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
M'HAMED BOUGARA-BOUMERDES UNIVERSITY

Facultyof Technology

Electrical Systems Engineering Department

Master memory

Presented by
AbabsaDounia
GheribiZohra

Sector: Telecommunications

Specialty: Networks and Telecommunications

Realization a Video Time Inserter by GPS timing and data

Defended on 26 / 11 / 2020 in front of the jury composed of:

BELKACEM	SAMIA	MCA	UMBB	President
SEDJELMACI	IBTICEME	MCA	UMBB	Examiner
MECHID	SAMIRA	MAA	UMBB	Reporter

Academic year: 2019/2020

Acknowledgments

First, we thank Allah Almighty for giving us the courage to carry out this modest work and support of our parents.

We would like to express our sincere thanks to our mentor Mr. Baba Aissa Djounai, for his support, helpful discussions with valuable and constructive suggestions during all this work.

We will be eternally grateful for the insight and expertise he shared with me and, most importantly, for providing us with an opportunity to cultivate our research skills. His enthusiasm for science served as an example and pushed us forward with great enthusiasm and vitality.

We thank Co-supervisor Mr. Akliouat Hacene for supervising, orienting, helping and advising us. We thank all the teachers especially Madam S. Mechid for our support and help.

We also thank the members of the jury and the president of the jury, for having read our manuscript and for taking a critical look at our work.

Our gratitude and thanks also go to all the researchers in the CRAAG internship center and especially Dr. Ikhlef Rabah for his help and instruction, without forgetting the big instruction we get from Mr Elhachmi Aichaoui.

To conclude, we would like to extend a special thanks to our parents, sisters and brothers, for giving us moral support, our friends and colleagues and finally all the people we knew during our studies.

Abstract

In this graduation master thesis, we studied and realized a prototype of a video date stamper based on the Arduino architecture. In addition, we coupled this electronic circuit with a GPS module for time base synchronization and tuned it to an OV7670 CCD Camera. After that, we studied the properties of the GPS system. Then, we displayed the date, the precise time and the accurate geographical location via a small TFT-type LCD Screen. Finally, we also recorded the dated video on the computer using software (IntelliJ Idea). This work falls within the framework of an initiation into research on precise time inserters to date transient astronomical phenomena as occultations.

<u>Key word</u>: *occultation, asteroid, time, GPS, frame, video, camera, VTI, IOTA, display, precise.*

Résumé

Dans ce mémoire de fin d’études de Master, nous avons étudié et réalisé un prototype d’un incrustateur de date précise vidéo basé sur l’architecture Arduino. Par ailleurs, nous avons couplé ce circuit électronique avec un module GPS pour la synchronisation de la base de temps et l’avons accordé à une caméra CCD OV7670. Après, nous avons étudié les propriétés du système GPS et affiché la date, le temps précis et la localisation géographique exacte par le biais d’un petit écran LCD de type TFT. Enfin, nous avons également enregistré notre vidéo datée sur ordinateur en utilisant le logiciel (IntelliJ Idea). Ce travail rentre dans le cadre, d’une initiation à la recherche sur les incrustateurs de date précise pour dater les phénomènes astronomiques transitoires, en l’occurrence, les occultations.

<u>Mots clé :</u> *occultation, astéroïde, temps, GPS, cadre, vidéo, caméra, VTI, IOTA, affichage, précis*

ملخص:

في إطار أطروحة التخرج لشهادة الماستر، درسنا وأنجزنا نموذجًا إلكترونيا يُدْخِل ويُظهر في فيديو التاريخ والوقت بدقة عالية ويستند على بنية **أَرْدوِينُو**. بالإضافة إلى ذلك، قمنا بربط هذه الدارة الإلكترونية بوحدة نظام التموضع العالمي **جي-بي-أس** لمزامنة القاعدة الزمنية وضبطناها على الكاميرا **سي-سي-دي** OV7670. ثم درسنا خصائص نظام **جي-بي-أس**، وقمنا بإظهار التاريخ والوقت الدقيق والموقع الجغرافي المحدد في شاشة العرض البلوري السائل صغيرة من نوع TFT. وأخيرًا، سجلنا مقطع الفيديو على الكمبيوتر باستخدام البرنامج (IntelliJ Idea). يندرج هذا العمل في إطار الشروع في البحث عن الدارات الإلكترونية التي تُدْخل وتُظهر الزمن بدقة عالية لرزنامة الظواهر الفلكية العابرة.

Contents

Abbreviation

VTI: Video Time Inserter

IOTA: International Occultation Timing Association

UTC: Universal Time Coordinated

TAI: Time Atomic International

UT: Universe Time

OSD: On Screen Display

NTSC: National Television Systems Committee

PAL: Phase Alternating Line

Led: Light emitting diode

Lcd: Liquid crystal display

TFT: Thin Film Transistor

EEprom: Electrically Erasable Programmable Read-Only Memory

Vsync: Vertical synchronization is technology responsible for synchronizing the frame rate

1PPS: One Pulse Per Second from GPS sensor

FPS: Frame Per Second

VGA: Video Graphics Array

Tables List

Figures List:

General Introduction

The advances in technology have made our research easier to conduct and achieve goals in various fields, using telecommunications system in order to characterize the small bodies of the Solar system knowledge. For this purpose, the applications of telecommunication are the most uses for collect the information toward the world. In general, these applications positioned in places far from the census and empty like the antennas, satellites, radars.

Furthermore, the study of asteroids is relevant and aims to understand how the solar system came into being. Therefore, an observation technique developed forward more than 30 years ago to characterize these celestial bodies. This technique studies stellar occultation by asteroids to determine the shapes and contours of these small celestial bodies. It consists of precisely measuring the brief disappearance produced by the passage of an asteroid between the Earth and a possible star that will be occulted. At a given time, an occultation band will pass through a place on Earth. By placing several observers all along this band and by precisely measuring the geographical position and time by GPS for each observer, we will then be able to characterize the asteroid.

In our project, we have been interested with the video time inserter and its role the precise time and date. The video time inserter is an electronic device, which have the particularity to inject into an analog or digital video a precise time and a location coordinate from a GPS data.

This work built to realize a box similar to the Video Time Inserter (VTI) which certified by IOTA Association which works in close collaboration with the International Astronomical Union and NASA. VTI box will be more chipper and available for all scientists to facilitate timing astronomical observations in our country.

We will use for our work an Arduino board, which simplify the uses of a microcontroller and of course the source of data GPS module to acquire the location and times by NMEA sentences.

For treating these sentences, we need an OSD Video shield who insert the data of GPS into the video obtained from the camera embedded in telescope.

Unfortunately, we run across the missing of OSD ships around the country and the difficulty to delivery it from others pays coinciding with the quarantine due to Corona virus, and for ensure to complete our project we try to replace the missing components by others for explain the role and benefits of our work.

Hence, in this memory we realize and simulate in the first part a system for obtained a data from a GPS module. In second part, we added a camera module for Arduino and try to combination theme into one system.

Our work contains and organize as following:

- The first chapter gives a brief presentation of the description of asteroids, the phenomenon of occultation in astronomy and their different types. In addition, it explains the measurement methods applied to obtain scientific data that can be used to process them.

- The second chapter illustrates a brief reminder of the different precise date video inserters and devotes another part to the study of the different properties and uses of GPS as a method of measuring precise time and place.

- The third chapter will deal in detail with the experimental part, which is based on the creation of a mini-prototype of a precise date video inserter based on the ARDUINO architecture.

Finally, a general conclusion will seal this final dissertation to describe the possibilities of improving this work.

CHAPTER O1:

OCCULTATION IN ASTRONOMY

I.1 Introduction:

In this chapter, we will present occultation in general, we describe the different types of occultation and how to observe them.

An occultation is an astronomical phenomenon, which happens when a star is totally or partially masked by another stellar object. Indeed, this object will pass between the star and the observer. Each occultation can be seen only at the right time in a specific geographical band. It should be noted that when the Moon moves in the night sky, it hides certain stars.

Therefore, we will focus in our memory on observation of stellar occultation by asteroids. This event is not rare but widespread. As long as there are a very large number of stars and asteroids in the sky then the probability that an occultation can occur is very high, so much so that we can speak of a dozen or more per day. It is interesting to note that the majority of occultation’s can only be observed with large telescopes, except in very rare cases when the stars are very bright and even visible to the naked eye. For example, on Thursday 20th March 2014 the bright star Regulus from Leo constellation, was occulted by the asteroid 163 Erigone and was observed in the United States and Canada. When a stellar occultation occurs, it takes about a few seconds may be more, may be less because it depends on the speed and size of the occulting celestial body. This technique will subsequently determine and characterize the edges and the shape of the asteroid. The measurements taken can also help to determine the distances between the stars.

Finally, they can detect a binary star, a natural satellite or even possible rings around the asteroid.

I.2. History of stellar occultation by asteroids:

In 1952, Gordon Taylor was the first scientist to try to predict possible stellar occultations by the four large asteroids ((1) Ceres, (2) Pallas, (3) Juno and (4) Vesta), the only ones for which fairly accurate ephemerides could be obtained. The first successful observation of a stellar occultation by an asteroid was (3) Juno and made on February 19th, 1958. This unique positive observation, undertaken by the Swedes Svend Ake Bjorklund and Svend Aage allowed them to deduce the minimum diameter of Juno. The second success was obtained at the observatory of Nani Tal in India and concerned the asteroid (2) Pallas on October 2, 1961[1]. It should be noted that the success was only partial, since at least three positive observations are necessary to determine a diameter. It was not until January 25, 1975 and the occultation of the star Kappa of the Gemini constellation by (433) Eros in the United States, that eight positive observations (and a few important negative observations) allowed us to establish the characteristic shape of the asteroid, a profile later confirmed when the American space probe. NEAR orbited it in 2001 [1].

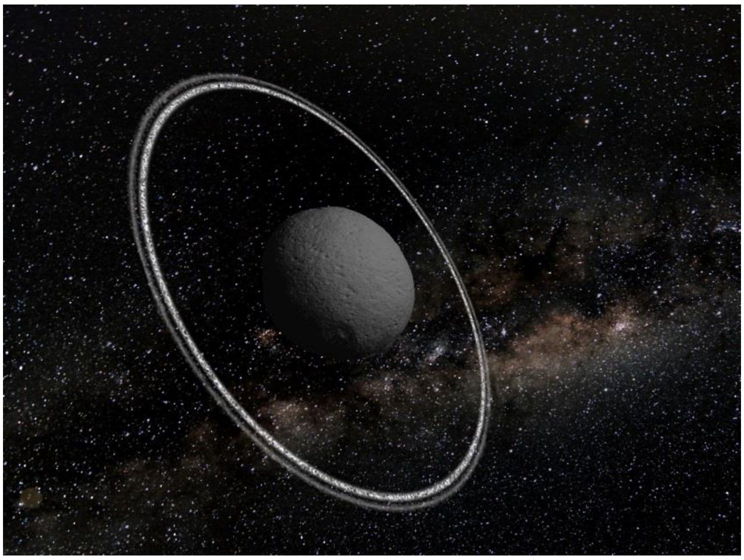


Figure I.1: The rings of the asteroid chariklo

I.3 Occultation in Astronomy:

I.3.1. Difference between occultation and eclipse:

According to Professor Bruno Sicardy from Paris Observatory, the word "eclipse" comes from *Greek* and means projection of a shadow on a celestial body, however the word "occultation" comes from *Latin* and means hide one celestial body from another. The figure 1 describes the difference between the two astronomical phenomena.

- An eclipse is a projection of a shadow a body

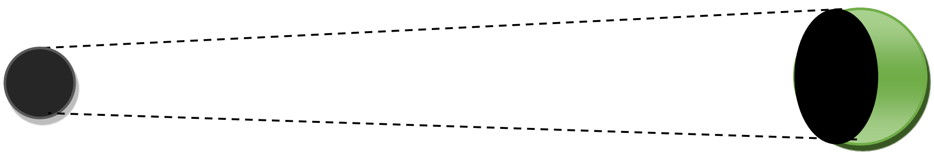


Figure I-2 – description of an eclipse

- Occultation is to hide a body by another

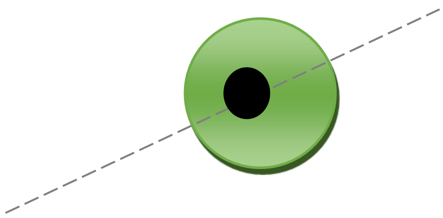


Figure I-3- description of an occultation

I.3.2 The Different types of occultation:

There are several types of occultation in Astronomy such as the solar eclipse by the moon, the transit of the planet Mercury and Venus on the apparent disk of the Sun, the transit of exoplanets through their stars, stellar occultation by the moon, stellar occultation by asteroids, mutual phenomena etc...

An occultation like a total solar eclipse that it is a very punctual event geographically and temporally, therefore exceptional. Eclipses characterized by a shadow and a penumbra, the duration of the shadow depend mainly on the size of the object in the solar system and the penumbra depends on the stellar diameter. This is a very simple measurement of a quantity that is otherwise inaccessible without interferometry.

I.3.3 Definition of an Asteroid:

Asteroids are small solid bodies in the solar system ranging in size from a few meters to several hundred kilometers in diameter at most. These rocky minor planets are remnants left over from the early formation of our solar system about 4.56 milliards years ago. It is assumed that asteroids are remnants of the protoplanetary disk that have not clustered into planets. Most of these small celestial bodies orbit the Sun between the planet Mars and Jupiter and form the main asteroid belt. A second belt exists beyond the planet Neptune and called the Kuiper belt. However, this remote zone of the solar system is made up of icy bodies unlike the main belt. According to the Minor Planet Centre, which is an agency that depends on NASA and Division III of the International Astronomical Union (IAU), there are 994 477 asteroids listed at the beginning of October 2020. Statistics estimate that there are millions more to be discovered [3].

The first asteroid was unexpectedly discovered by the Italian astronomer Giuseppe Piazzi at Palermo Observatory in Sicily. The celestial object was named (1) Ceres later.

The Figure 2 describes the asteroid (243) Ida which was flown by the American spacecraft Galileo on August, 28th 1993.

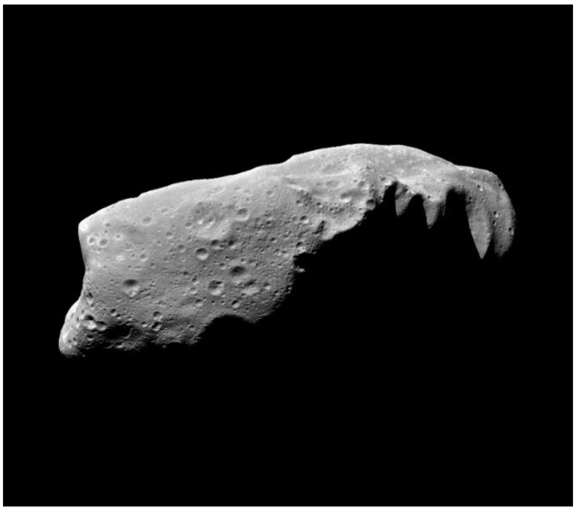


Figure I.4: Image of (243) Ida asteroid taken by the American spacecraft Galileo on august 1993

I.3.4Presentation of a stellar occultation by an asteroid:

The star is usually the brightest component of the occultation. The asteroid is usually several magnitudes fainter than the star and often too faint to be detected in a small telescope.

The observation of a stellar occultation makes it possible to carry out a measurement of the dimension of an asteroid.

This measurement has two great qualities: It is direct and very precise.

The Figure I-4 describes the phenomenon of a stellar occultation by an asteroid.

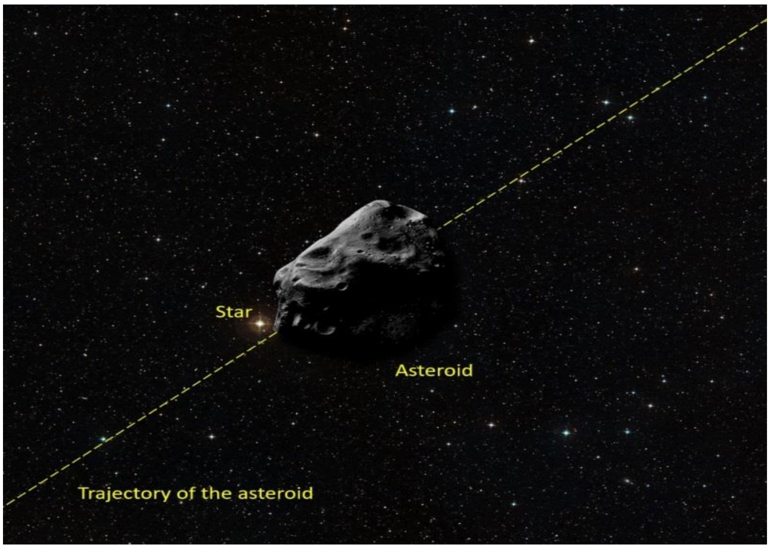


Figure I-5: A stellar occultation by an asteroid

I.4Observation and Occultation:

I.4.1 Observation principle:

The observation of a stellar occultation by an asteroid consists to measure the time passage of an asteroid, which passes in front of a star. Let us first consider the star as a point source of light. Since the asteroid has a certain apparent diameter, the star will suddenly disappear for a few seconds to a few tens of seconds and then reappear.

As for a total solar eclipse, the phenomenon will be observable only inside an occultation band, representing the trajectory of the asteroid's shadow on the Earth's surface. On either side of this band, the asteroid will not occult the star.

Knowing the apparent speed of the asteroid, the duration of the star's disappearance (in seconds) will be directly convertible into a dimension on the asteroid (in kilometers). The precise times of disappearance and reappearance will be necessary to position this measurement in space and thus assemble the observations coming from different observers.

Let to consider an asteroid of 200 km in diameter that we place 300 million km from Earth. The figure 4 describes 3 images:

The Image (a) shows how it looks when it is observed by an 8-meter-diameter telescope. The resolution obtained is of the order of 60 km.

The Image (b) shows the result obtained on the same asteroid observed by 25 observers using the occultation method with small telescopes. The resolution obtained is of the order of 1 km.

The Image (c) shows the result when a spacecraft flies over this asteroid. The resolution obtained is of the order of 0.01 km.

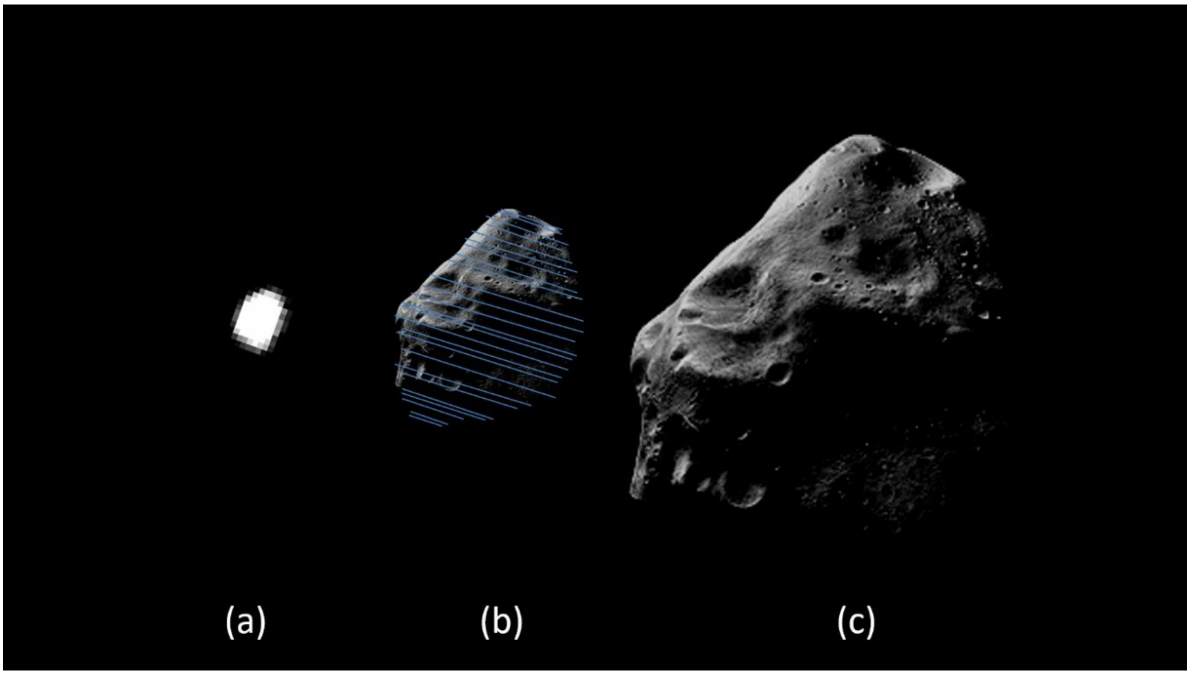


Figure I-6: The description of an asteroid by telescope in (a), deduced by a stellar occultation in (b) and photographed by a spacecraft by in (c)

The measurement obtained by a single observer is called a chord. It represents a single segment, measured from one edge of the asteroid's contour to the other.

If several observers observe from different locations across the width of the occultation band, several chords of different lengths are obtained, corresponding to different parallel segments crossing the contour of the asteroid.

If there are a large number of observers, the complete profile of the asteroid will be obtained, giving a true "photograph" of its contour at the moment of occultation, with its characteristics and bumps.

On 19 July 2011 and thanks to measurements obtained by 56 observers around the world, astronomers traced the contours of the asteroid (90) Antiope, which turned out to be a double [4]. This is a plot of observations done by members of the International Occultation Transit Association (IOTA). The figure 5 describes this result which each line represents the light hitting one telescope on the ground.

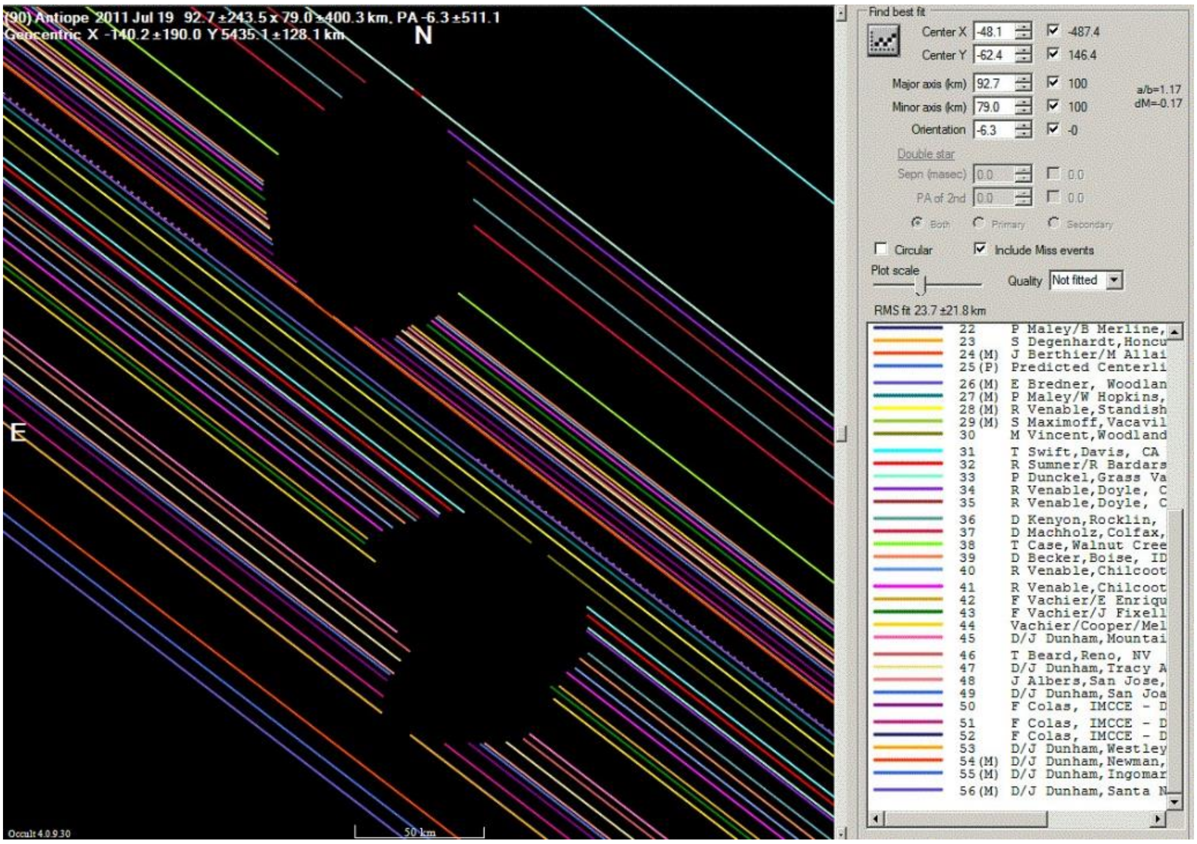


Figure I-7: Plot of 56 observers around the occultation band describing the binarity of the asteroid (90) Antiope

Knowing, by photometry, the absolute magnitude of the asteroid at the moment of occultation, the albedo of the body is then deduced, which will constrain its composition and therefore its mass. Several profiles obtained during different occultations by the same object will finally make it possible to build a 3D model of it.

The observation of a stellar occultation by an asteroid also allows:

- To improve knowledge of the orbit of the asteroid. If the position of the star is known with precision, we will be able to assimilate this position to that of the center of the asteroid at the time of the event, and obtain an extremely precise astrometry point (better than 10 milli arc second).

- To detect binary asteroids or a possible satellite. Observing a star as an asteroid cross near the line of sight is one way to scan the space around the asteroid. A secondary disappearance can then be detected, revealing the presence of an asteroid satellite.

- To measure the diameter of the target star. As the usual resolution is of the order of 1milli arc second, if the star underlies a larger diameter there is a progressive disappearance and reappearance. The duration of this progression (which also depends on the orientation of the asteroid's limb in relation to its motion) makes it possible to give the target star a minimum diameter.

- To discover tight binary stars, undetectable by other methods. In this case, a two-step disappearance is observed, betraying the presence of a companion at the target star.

- To detect eventual rings around the asteroid like (10199) Chariklo which has a diameter of 250 kilometers and surrounded by two narrow dense rings of 7 and 3 kilometers wide. [4].

Its rings were discovered on June, 3rd 2013. On January, 21th 2017, astronomers discovered another ring around the dwarf planet (136108) Haumea [5].

I.4.2 Equipment:

For a positive or negative observation result, the observer needs a special equipment to detect the occultation and record it accurately as shown in the figure I-6.

- Telescope: In Algiers Observatory (CRAAG), they use some telescopes, which have different diameters as 20centimeters, 28 centimeters, 30 centimeters and 80 centimeters.
- A sensitive CCD Video Camera: As Watec 910 HX/RC, Raptor (Photonics), CMOS Camera QHY 174 M GPS or Runcam Eagle 2 Pro CCD camera.
- GPS Time Inserter: It’s an electronic device coupled to a GPS module, which gives a precise source of time as IOTA VTI or TIME BOX.

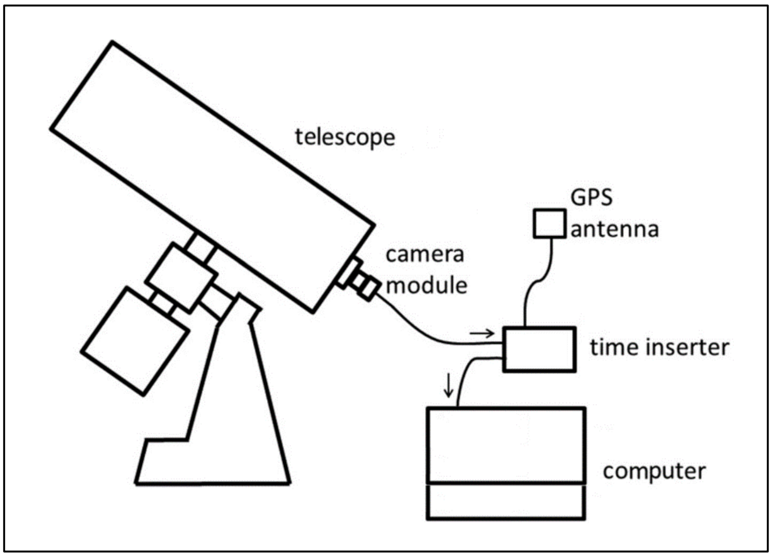


Figure I-8: Representation of the optimal configuration for the observation of stellar occultation by asteroids using telescope, CCD Camera and Video Time Inserter coupled by a GPS module and antenna.

I.5 Conclusion:

In this first chapter, we defined what asteroids are, we presented what an occultation is, and then we briefly explained in a succinct way on stellar occultation by these small bodies.

Then we described a short history of the observation of these astronomical phenomena.

Finally, we highlighted the interest of the study of these asteroids using this observation method for a better understanding of the birth of the solar system.

It should be noted that astronomers use telescopes coupled with CCD cameras to observe these occultation. However, in order to be able to plot the contours and obtain the shapes of asteroids, other technical means are required. These means appeared thanks to the development of the space era, which stimulated technological innovations, in this case, the global positioning systems (GPS) for an exact knowledge of the geographical coordinates of any place on Earth but also to measure time with accurate precision. In Chapter 2, we will discuss these techniques used to accurately measure time.

CHAPTER 02:

THE VIDEO TIME INSERTER

II.1 Introduction:

The precise dating of certain astronomical phenomena as transit and occultation, are essential for the study and characterization of these small bodies. An adequate electronic device called an inserter coupled by a GPS necessary to carry out this experiment.

II.2 USES OF GPS:

II.2.1 Definition of GPS:

GNSS (Global National Satellite System) is an umbrella term encompasses all global satellites positioning system (GPS), this include constellation of satellites from GPS (USA), CLONASS (RUSSIAN), BEIDU (CHINA), GALILEO (European).

The GPS is satellite-based navigation system that was developed by by the United States Department of Defense (DOD) in the 1960s, it was developed as a military system, and however it was later available for civilians' users.

GPS consists of a constellation of 32 operational satellites (24 usefully and 8 backed up) allows instant positioning accuracy of a meters or in some cases in the scale of centimeters.

To ensure continuous worldwide coverage, GPS satellites arranged in 6 orbits plane with 4 satellites per plane. This satellite sends time signal which is received by our GPS module to calculate its location that latitude, longitude and elevation using the triangulation method

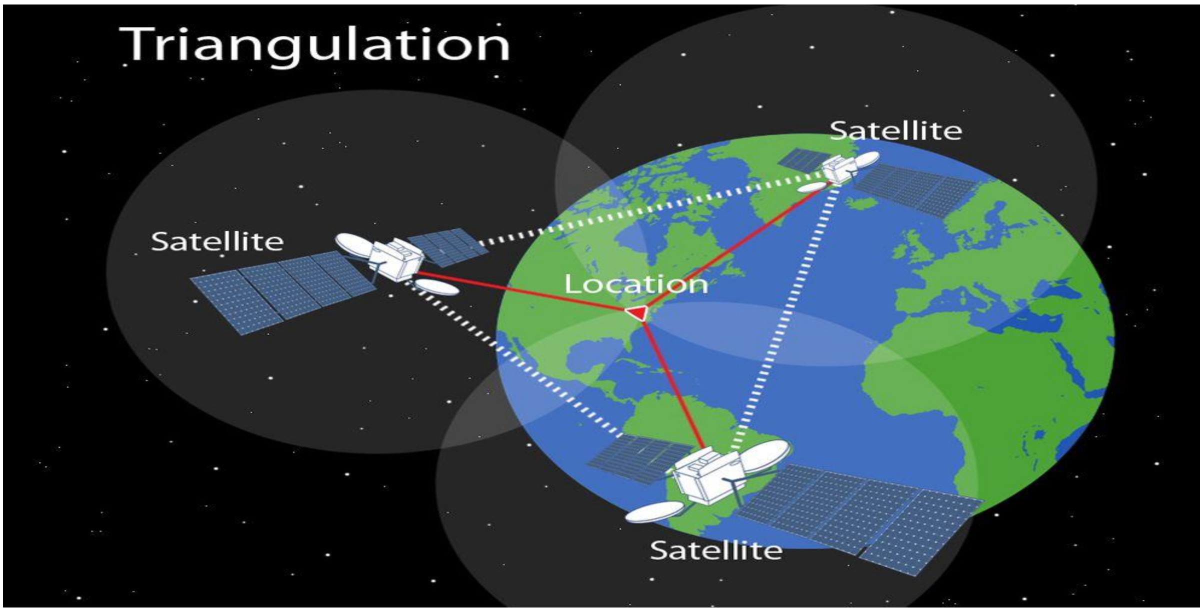


Figure II-1: Triangulation method to locate any position on Earth by GPS satellites

II.2.2 GPS SEGMENTS:

II.2.2.1 Space segments:

The space segment consists of 24 satellite constellations placed in 6 circular orbits approx. 22,000 km from the center of the Earth)

- Each satellite carries an atomic clock
- Each satellite completes 2 orbits per day.
- 24 hours complete GPS coverage anywhere on the Earth.
- Accuracy: 21 meters 95% of time each GPS satellite transmits a signal which has a number of components**:**

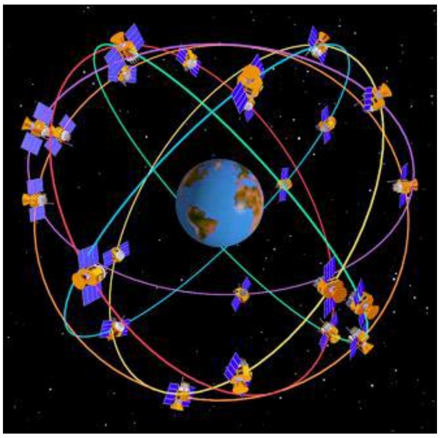


Figure II-2: Position of satellites

II.2.2.1.1 Sine waves (carrier frequencies):

The satellite signals are transmitted on two different carrier frequencies called L1 and L2, the errors produced by the ionospheric refraction of the wavelengths.[7]

The signals carrier GPS generated from the fundamental clock frequency of satellite f_0=10.23MHz

Band	F [MHz]	λ [cm]
L1	154 f_0 = 1575.42	~ 19
L2	120 f_0 = 1227.60	~ 24

Table II-1: The different frequency

II.2.2.1.2 Digital codes:

The code C/A is a pseudo-random binary consists of 1'023 elements, which repeats, with a period of 1milli second

The P code is called the precise code, its use requires access to specific information and suitable equipment

- The carrier frequencies and the codes are used to determine the distance between the user's receiver and GPS satellites.

II.2.2.1.3 Navigation message:

the navigation message contains some of the information the receivers need to determine positions such as:

- Synchronize internal clock for the receiver
- Time correction
- Hook the other satellites

The navigation message and the codes added to the carrier as binary bi-phase modulations.

II.2.2.2 Control segment:

The control segment consists of five terrestrial stations, Monitor Station Network (MSN) with a Master of Control Station (MCS) located in U.S.A Colorado Springs and ground antenna.

The location of these stations toward the earth ensures to track the GPS satellite by 92% of the time, system integrity and behavior of the satellite atomic clock, atmospheric data, the satellite almanac.

Figure II-3: The GPS stations in the world

II.2.2.3 User segments:

The user receiving equipment processes and decodes signals the navigation transmitted by the satellite. It is possible to do:

- Select several satellites among those, which are visible and acquire the GPS signals.
- Tracking the chosen satellites.
- Extract the navigation message and calculate the solution of position and time.

II.2.3 GPS time:

The GPS control segment provides a continuous time scale by using an atomic clock at the monitors stations. Its calculated from the following elements:

- On-board clock
- UTC (USNO)
- UTC (AMC)

II.2.3.1 Coordinated Time Universal:

The coordinated time universal is a number of seconds we added or removed by the international atomic time (TAI) for keeping in the same range of seconds of the time universal (UT).

UTC signals are synchronized and broadcast regularly by various radio stations (e.g., WWV in the US) and satellites (e.g., GEOS, GPS**).**

- Have propagation delay due to speed of light, distance from broadcast source, atmospheric conditions, etc.
- Received value is only accurate to 0.1–10 milliseconds.

II.2.4 NMEA Operation:

The National Marine Electronics Association (NMEA) has a standard for the formatting of Global Positioning System (GPS) information. There are quite a number of different string formats, called NMEA sentences. A basic problem with NMEA is that most third-party GPS receivers send different NMEA sentences one after the other, and usually there is no fixed timing relationship at which point in time a certain NMEA sentence is sent after the beginning of a new second. So, if an application receives a particular string it doesn't know if the string has been sent at the beginning of a second, or at the end, or shortly before the second rolls over to the next one.

That's why usually a **1 PPS signal** is required with NMEA to get this working properly. The NMEA sentences indicate the absolute time, which is sent at a random time during the second, and the 1 PPS signal indicates when a new second starts, so the combination of both is required for good time synchronization.[8]

Example:

GGA - Essential fix data, which provide 3D location and accuracy data.

$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*42

Where:

GGA Global Positioning System Fix Data

123519 Fix taken at 12:35:19 UTC

4807.038,N Latitude 48 deg 07.038' N

01131.000,E Longitude 11 deg 31.000' E

1 Fix quality: 0 = invalid 1 = GPS fix 2 = DGPS fix 6 = estimated (2.3 feature)

08 Number of satellites being tracked

0.9 Horizontal dilution of position

545.4,M Altitude, Meters, above mean sea level

46.9,M Height of geoid (mean sea level) above WGS84 ellipsoid

(empty field) time in seconds since last DGPS update

(empty field) DGPS station ID number

*42 the checksum data, always begins with *

II.2.5 HOW WE CHOOSE A RECEIVER EQUIPMENT?

In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock.

So, we should to select our needed according to:

- ✓ Application (tracking)
- ✓ Power consumption requirements (medium)
- ✓ Operational environment (spatial)
- ✓ Signal processing requirements (high)
- ✓ Cost (cheap)
- ✓ Data exchange standard

II.3 THE INSERTERS:

II.3.1 Definition of inserters:

The inserter is an electronic device, which have the particularity to inject into an analog or digital video a precise time for each frame. Among the inserters that were used in the framework of stellar occultation by asteroids:

- KIWI
- IOTA VTI
- Time box
- GPS Box 3sprite
- QHY147 M GPS

II.3.2 General Schema synoptic:

The operation for using an inserter can be resumed in the schema bellow and as we can see:

1- The inserter gets the video signal (NTSC or PAL) from the camera
2- The inserter processed the video inserted by the GPS data
3- The visional tools display and rad the new video treated

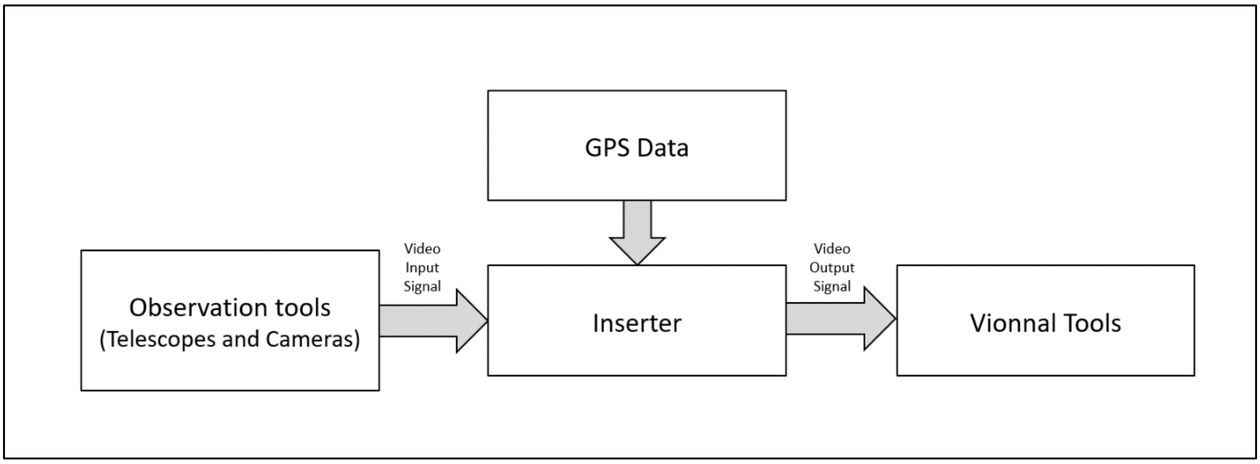


Figure II-4: schema synoptic of inserters work

II.3.3Different type of inserter:

All the video time inserters have the same role however every single of theme provide information according to its programming and have a specific design

II.3.3.1 KIWI-OSD

1. Definition:

A kiwi-OSD inserter is a microcontroller which introduce a service of timing an existing video inserter by GPS derived time.

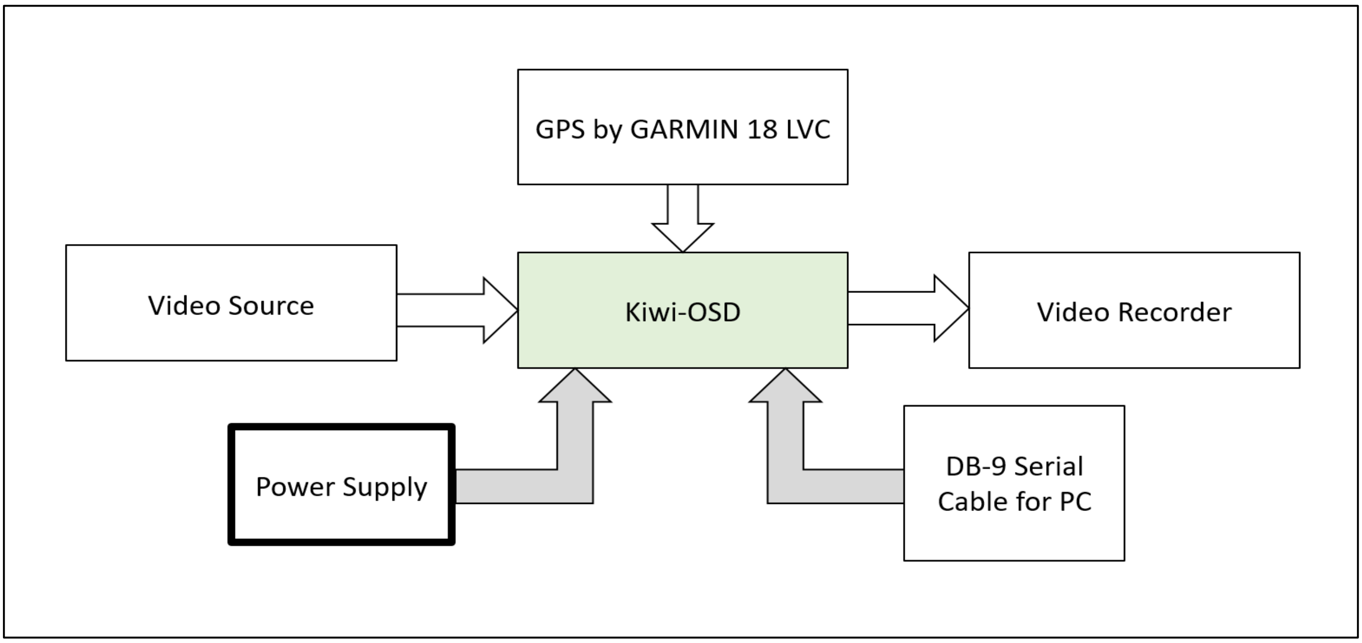


Figure II-5: Schema represented the kiwi-OSD inserter

2. KIWI-OSD Interfaces*:*

- ***Video source:*** Represent the video camera how can operate NTSC, PAL, SCAM video with female RCA cable.
- ***Video output:*** Represent the video recorder that was monitor with the Kiwi-OSD box and it linked with a mal RCA such as VCR or camcorder.
- ***Power supply:*** The Kiwi-OSD require a direct current (DC) power must be between a 9V TO 15V.
- ***Kiwi-GPS:*** All models of the KIWI-OSD are wired with either a DIN-5 cable or connector that is directly with the Garmin KIWI-GPS.

- ***DB-9seriel cable:*** Kiwi-OSD models are equipped with a serial cable that provides the means for the GPS to communicate with a Personal Computer (PC).

II.3.3.2 TIMEBOX:

1. Definition:

The Time Box is an electronic inserter, which has the particularity of synchronizing the clock of a computer or a server with Coordinated Universal Time (UTC). This device is designed for the precise timing of astronomical phenomena, but also for other applications that require precise dating with an absolute time reference, using digital cameras. The dating of stellar occultations by asteroids should be carried out in relation to an absolute time scale in order to extract and compare the recordings made by different observers around the world.

The chosen time scale is Coordinated Universal Time (UTC), which is the main time standard regulating clocks and time (McCarthy et al. 2009). Stellar occultation is a proven method used to determine the size, shape and position of asteroids, as well as the topology and orbit of satellites (Trahan et al. 2014).

Time Box retrieves UTC time from GPS satellites and inserts UTC time in three different modes:

- LED triggering (with an accuracy of less than 8 microseconds).
- Computer clock synchronization (with plus or minus 2 milliseconds).
- A camera triggering which requires an external trigger with an accuracy of less than 1 millisecond.

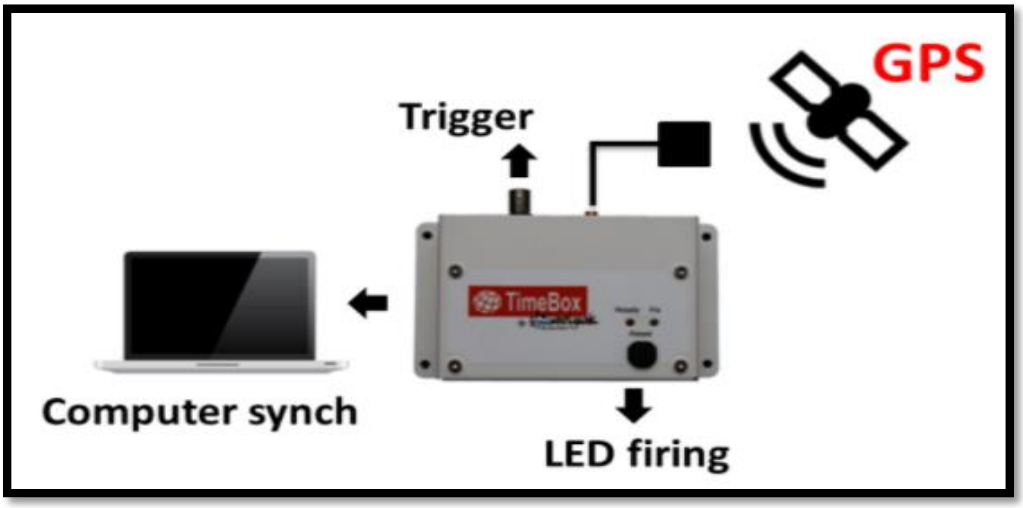


Figure II-6: represent a Time Box

II.3.3.3 GPSOXSPRITE3:

To provide a precision time and date display combined with GPS position, the video text overlay unit uses the precision one plus per second (1PPS) time base from an integer GPS receiver to drive it display, each frame referenced to the UTC time generated by the GPS receiver

1. The GPSBOXSPRITE3 Connections:

- **Video In/Out*:*** should video In or Out already made before the system powering up
- **GPS In**: this interface attached with the GPS active antenna supplied, the optimal accuracy with result from the antenna being placed with clear 360° view of sky
- **GPS Out**: the output of 3.5 mm jack socket connector is standard NMEA 0183 RS232 serial data, the GPRMC, GPGGA, GPVTG data are the only sentences are transmitted.
- **9-12 DC Regulated*:*** The Unit requires a regulated power supply connected via the 2.2 mm power connector, and a power button beside it to switch the unit on or off

FigureII-7: GPSBOXSPRITE3

II.3.3.4 QHY174M-GPS CAMERA

Using the analog video camera and a video time inserter are now standard for occultation's work, but considering the precise of timestamping drive the scientists to sophisticated a digital camera with an integer GPS called the QHY174M-GPS.

The QHY174M-GPS camera was choosing by NASA with the NEWHORIZON teams who captured an occultation for the Kuiper Belt object known as MU69 2014 (486958) Arrokoth by Marc BUIE and Alan STERN

Figure II-8: represent QHY174M-GPS CAMERA

1. **Definition:**

The QHY174M-GPS Camera provided a high precise timing of multiple exposure per second at many different sites synchronized in the same time for each frame.

The QHY174M-GPS Camera record also with a microsecond precision the global shutter exposure starting and ending time, due to its built-in LED pulse calibration.

2. **Operating mood:**

With the QHY174M-GPS Camera we can work in both Master and Slave mode.

- ❖ When we choose to operating with a Master mode the camera is free running and the internal 10MHz GPS synced clock measure and record the shutter's opening and closing time.
- ❖ However, with Slave mode we define a target for stat time of an exposure and declared the interval period for two frames.

II.3.4 IOTA VTI:

II.3.4.1 Definition of the VTI:

The IOTA VTI is based GPS video time inserter developed by Tony Barry, David Gault, for the astronomical occultation, it takes PAL or NTSC video from a camera attached to telescope with a great precise of time and location by an integer GPS.

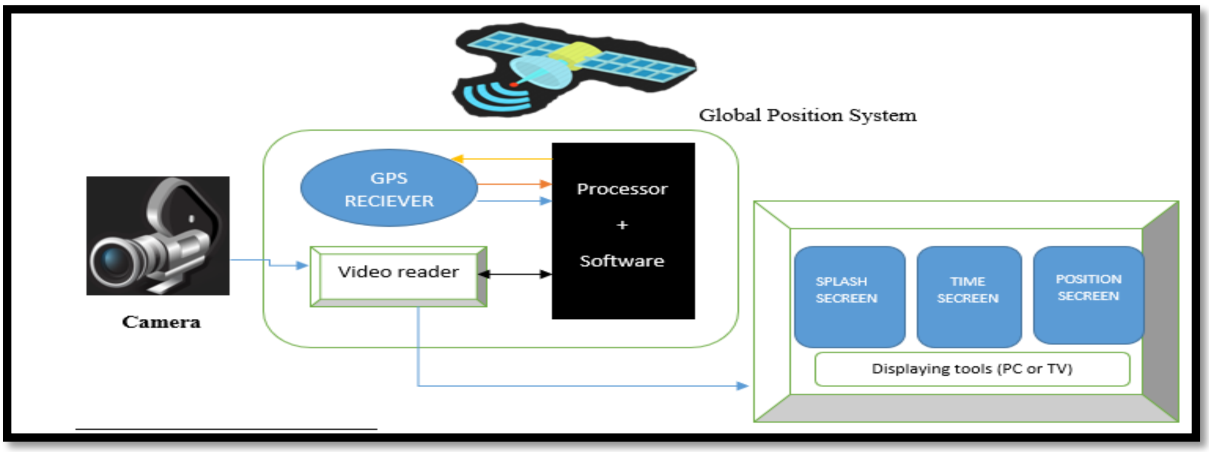


Figure II-9: for the function of IOTA VTI

II.3.4.2 IOTA VTI Box:

II.3.4.2.1 Rear panel

- **In/out interface:**

➢ The input interface inserts a signal with PAL or NTSC format according to the camera uses.

➢ The output interface provides a signal video treated with time stamp UTC and will carry.

- **USB / Socket Power:** Are used for a power supply, and it should be about 12V DC for feed the system up of IOTA

II.3.4.2 Front panel

- **LED's:**

GREEN LED for camera Led to indicate a good video in feed.

YELLOW LED for viewing the 1pps Led of the production VTI.

RED LED for confirm the power attached and system starting up.

- **Slide Switches:**

- **TV Safe Area / Full Screen Switch:**

The output monitor display or record the TV-safe area of video transmission, the panel switch must be fixed, this will place all the information in the TV-safe area. The power cycle is required for the change to take effect in the software.

✓ Deferent between a full screen and TV safe area:

- Full screen some text is chopped off on a TV monitor.
- TV safe area all the text is visible on a TV monitor.

- **Time / Position Switch:**

➢ **Position screen:** It's display information of GPS the date, the exactly time and the geographic location also all the VTI information (latitude, longitude minutes, decimal minutes).

➢ **Time screen:** The line of time screen displays GPS information, UTC system (HH:MM: SS)

There is an interval of 100 microseconds since the most resent 1PPS and the number of video fields counted since power was applied or the Reset switch was pressed.

II.3.4.3 Different versions of IOTA VTI:

The IOTA teams create the first version of IOTA VTI v3 and continued to sophisticate it into a new version IOTA VTI v2, which was more similar to v1. Later and by collaboration with Walter MORGEN, they up grade into newer version IOTA VTI v3, [9]

The IOTA VTI v3 provide much better performance with multiple function added.

Figure II.10: Represent the difference in design between the version

V1 AND V2	V3
• IN / OUT • POWER SUPPLY • RESET BUTTON • USB	• IN / OUT • POWER SUPPLY • RESET BUTTON • DARK • SERIAL DONG • ANNTENA EXT

Table II.2: represent the difference between the 3 versions

II.3.4.4 The supplement function of IOTA VTI v3:

- Dark interface: dark switch allows dark frames to be made, for subtractions of darks from the recordings. This button erases the OSD and can only activated to the position screen.
- Serial dong: this serial provides an output for listen to the NMEA sentences that given by GPS, which requires an FTDI drivers and software.
- External antenna: this function added for a specific situation where we had to operate at site with a poor GPS reception. When we replaced for an external antenna the GPS will auto switch from internal to external antenna [10].

- **Error messages:**

IOTA engineering modified the VTI for display on screen an error message to provide a good quality of timekeeping with minimal fuss, and to alert users this error message will appear within on seconds if there is an event occurred

The error and its type reported on the top of time screen by displaying one error per line.

Error	Name	Details	Version
1	UTCdidnotchangeCorrectlty	A 1PPS was detected, and ZDA information described it, but the description was not what was expected.	v1 & v3
2	NoPPS	A One Pulse Per Second (1PPS) was not received.	v1 & v3
3	NoZDAmsg / NoGGAmsg	No useful NMEA Sentence was received	v1 & v3
4	LoopTookTooLong	The main loop took too long to write the Time message properly on screen. This is set at 15 msec (PAL) and 12.5msec (NTSC).	v1 & v3
5	FailedBoardTes4t	The memory check routine detected memory contents were not what they should have been. This also puts a message across the center of the screen. If this error appears, the most likely cause is ionising radiation (gamma rays) or particle strike on one cell of the controller memory.	v1
6	PPStooQuik	may occur while the unit is re-stabilising after a Loss Of Signal.	v1 & v3
7	NoGGA	GGA sentence was delayed. This error will shut down the UT display for five seconds until the unit has recovered. If it occurs frequently, reposition the antenna away from sources of RFI.	v3
8	TwoGGA	Two GGA sentences were received. This will occur in tandem with and just after a NoGGA error	v3
9	AntAdvis	The unit received an unexpected antenna advisory message while in Time mode	v3

Table II-3: Represent the error messages

- **Video Frame, Field Type and Frame Central Timing**

The video stream has codes to identify an even field type from an odd field type, IOTAVTI can read the field type code and action the 10th millisecond display to put the timing for the Even field on the left and Odd field on the right. It appears that the sequencing method:

❖ (even odd), (even odd), is the most common.

❖ (odd even), (odd even), is somewhat less common.

❖ some will even assemble a pseudo frame from (even even), (even even) fields, and actually, ignore the odd fields, (or vice versa).

Obviously, this method is not desirable because the half data of the camera sees are tossed away by the recording equipment. IOTA-VTI has the means to demonstrate and identify field type.

II.3.4.5 VTI Timestamp verification:

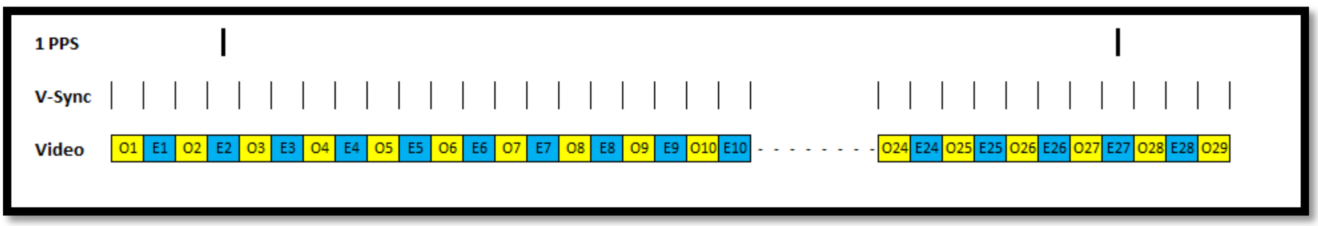
An occultation recording aims to capture an UTC time, and allows detection of the presence of an eventual atmosphere or/and satellite. These measurements depend on the time stamp of each frame of the video recording referenced by UTC.

II.3.4.5.1 Methods of timestamp:

For most occultation event systems are rely to Global Position System which obtained a based time source by using:

- ❖ UTC (Universal Time Coordinated) for fidelity.
- ❖ NTP (Network Time Protocol) to synchronize the imaging system computer clock

Accuracy of time stamp aims to be with in a millisecond of true by using the previous methods. The inserted millisecond time value is derived from UTC and video signal.



Schema II-11: Representation of the timestamp methods

II.3.4.5.2 VTI time stamping of an output:

A timestamp is a sequence of characters or/and encoded information indicating when

a certain event occurred, usually giving date and time of day, sometimes accurate to a small fraction of a second

Video Time Inserters (VTI) using GPS time are working very accurate and are able to time stamp every single video field of the analog video signal with an individual UTC time in a tolerance range of +/- 1 millisecond. The millisecond time value is derived from the GPS time signal and an internal counter running with quartz oscillator accuracy.

A VTI device only inserts time stamps in the current video field signal but never will add a delay to the video signal. So, the signal is always passing through the VTI without any noteworthy delay action

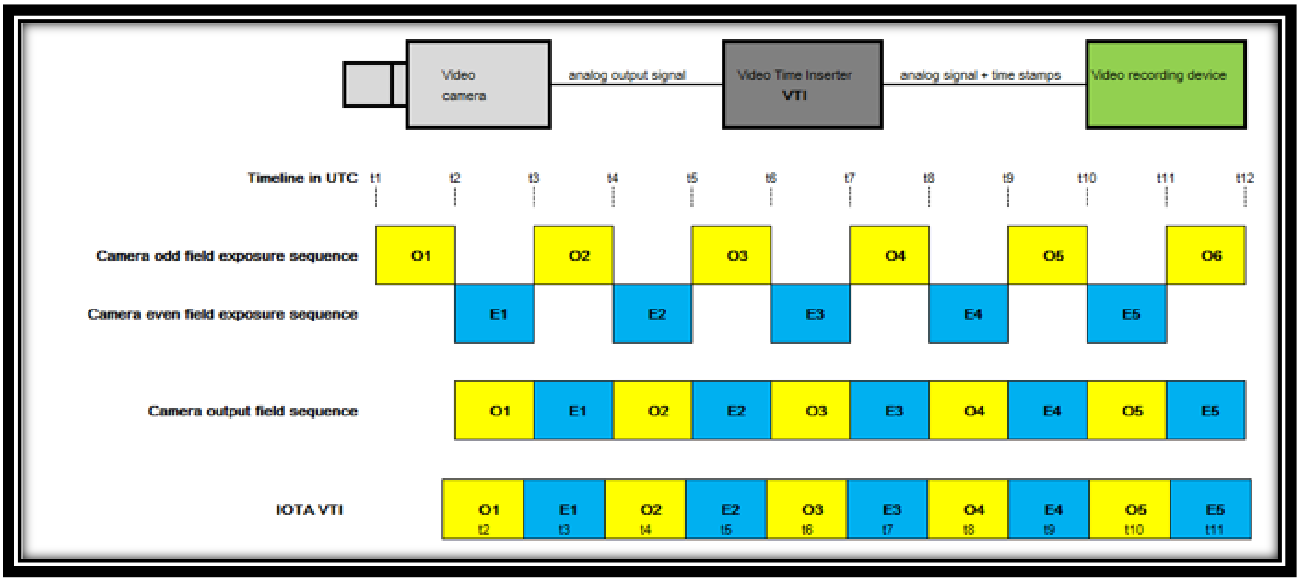


Figure II-12: Representation of VTI time stamping of an output

➔ IOTA VTI inserts one-time stamp representing the start time of the current field output.

II.4 Conclusion:

For an optimal measurement of the disappearance and reappearance of a star occulted by an asteroid, we need a sensitive CCD camera connected to a video Time inserter coupled with a GPS.

Indeed, this electronic circuit has the particularity a precisely dating and display it on a video for each frame. We described in this chapter, the aim and the proprieties of the Global Positioning System (GPS). Then, we explain how to use it for operation of several inserters. Astronomers to characterize asteroids by the occultation method use these circuits. In Chapter 3, we will discuss about the montage and realization a prototype of a Video Time Inserter.

CHAPTER 03:

REALIZATION A PROTOYPE OF VTI

III.1 Introduction:

This chapter was supposed to be a full description about the realization of a cheapest version of a VTI inserter by using a hardware part (Arduino board, GPS NEO-6m module, OSD video shield) and a software part (Arduino IDE) to montage and modifying our needed. However, we run across a pickle and the hardest one was the missing of OSD video shield chips around the country.

Hence, we face the reality and the time and decide to realize a mini prototype for explaining the role of a VTI inserter.

So, in this chapter we will explain the original VTI which supposed to realize. Then we will pass to start a mini prototype and descript the entire work (hardware and software), this work will provide the same role of the IOTA

Finally, we will discuss with the results that our prototype gives and its benefits.

III.2 Concept of a VTI Box:

The main role of a VTI box is to manage the instruction and the data came from both the camera capture (signal video) and the GPS receiver, and to made it right we need a microcontroller to organize and execute the orders between thee different components.

And for realize a VTI box we need as a main component:

III.2.1 Arduino UNO board:

The Arduino model is a platform consisting of an electronic board, a hardware and software environment based on easy-to-use, with a micro-controller which set the instruction send.

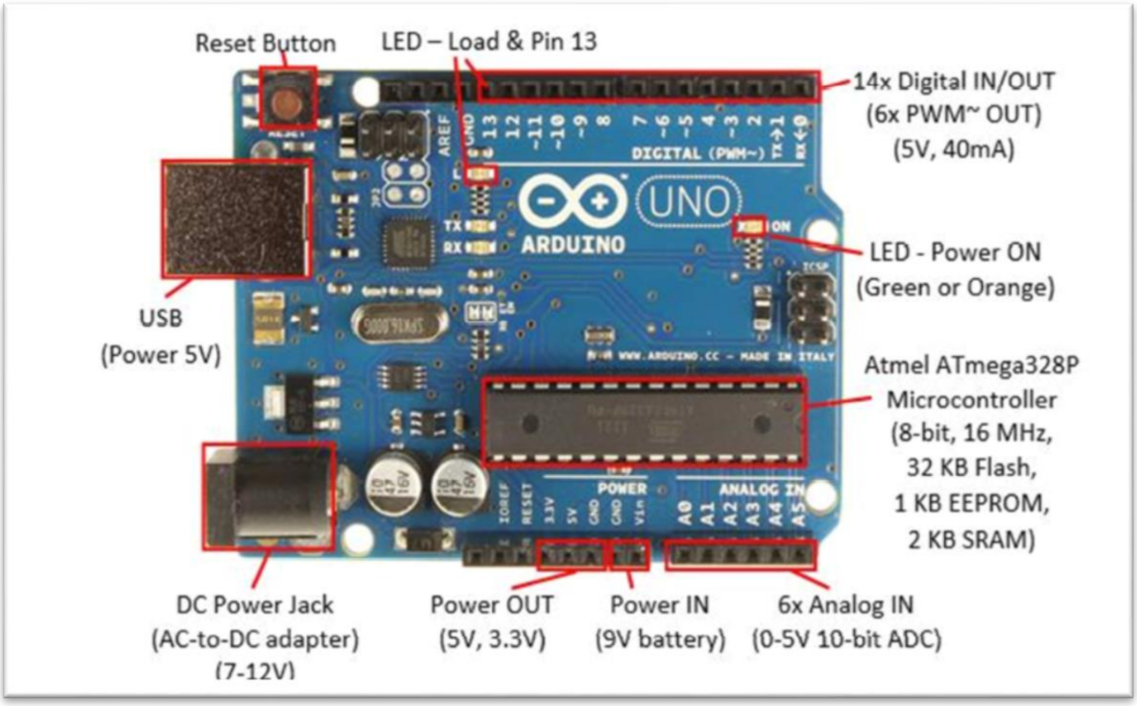


Figure III-1: Arduino UNO board

III.2.2 OSD Video Shield:

This is a MAX7456 OSD (On Screen Display) shield for Arduino. It can easily interrupt and overlay text and/or graphics onto a video signal (PAL or NTSC). It's just about “plug-and-play” with an Arduino board. Plug this shield on Arduino main board, uploading test sketch. Plug in your video signal to “Video In”, plug your TV into “Video Out”.

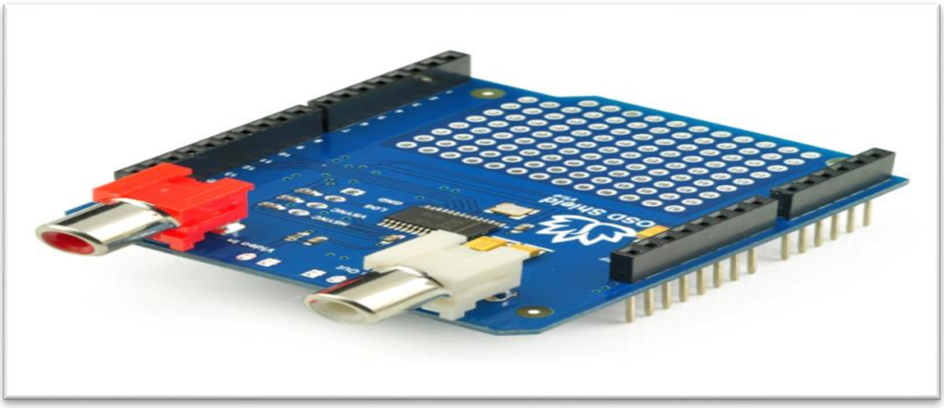


Figure III-2: OSD Video Shield

III.2.3 GPS Module:

The Ubox NEO-6M GPS engine on this board is a quite good one, with high precision binary output. It has also high sensitivity for indoor applications. The GPS module have a battery for power backup and EEprom for storing configuration settings.

The antenna is connected to module through a cable which allow for flexibility in mounting the GPS such that the antenna will always see the sky for best performance.

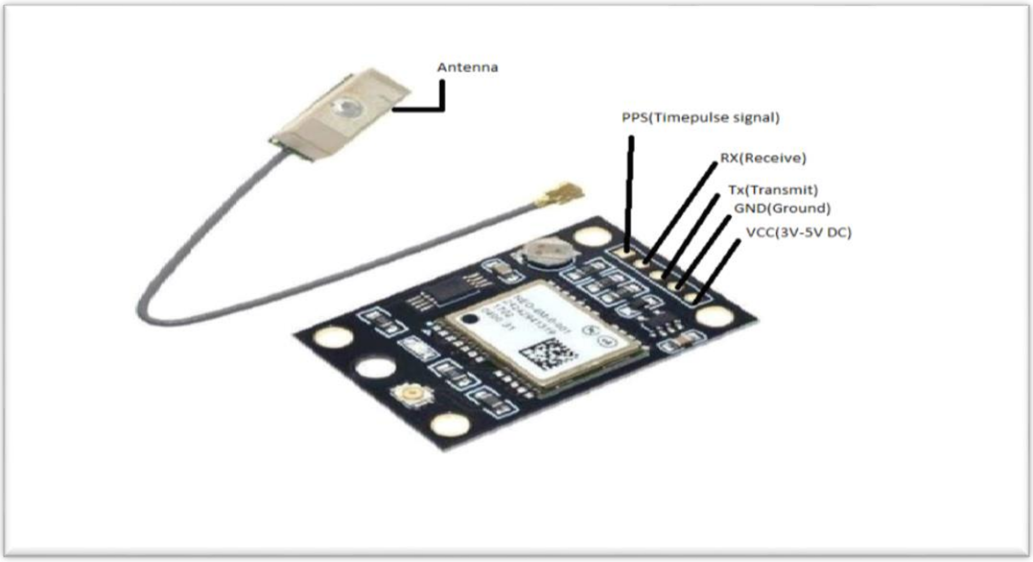


Figure III-3: GPS module with 1PPS

✓ PPS should be connected to the clock pulse output (CPOUT) of an MCU. This pin is unconnected if GPS module is connected to a computer.

III.3 Montage of a VTI Box:

The montage of a circuit final is shown in the figure bellow. We putting the OSD shield above the Arduino board and we linked other ships.

We need in this montage:

• Arduino UNO R3 board

• GPS U-Blox NEO-6m module

• Video OSD Shield module

• Universal PCB

• Red LED of 5 mm

• NPN transistor

• 3 switches

• 470 Ω and 10 k Ω resistors

• wires (jumpers)

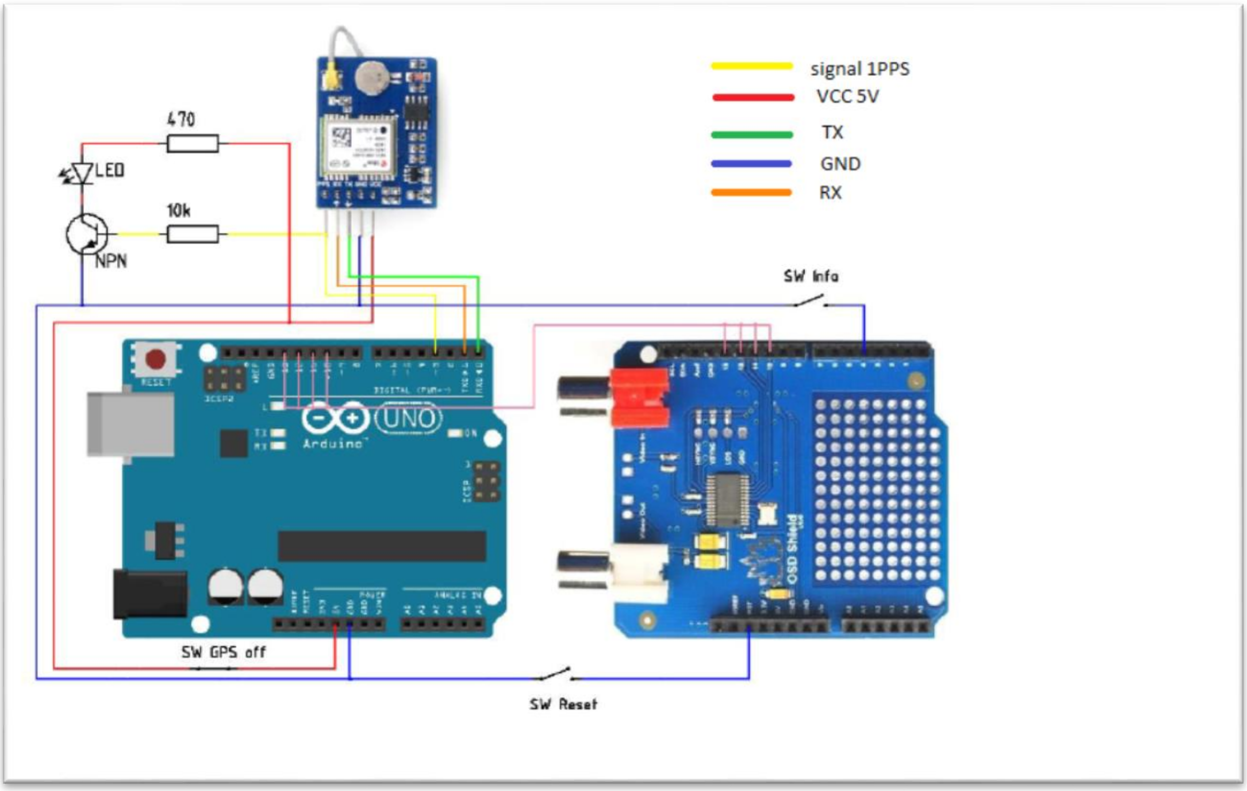


Figure III-4: Montage of a VTI Box

Unfortunately, we face the missing of the OSD Video shield ships which allow to drive a signal video (NTSC or PAL) from the CCD Video Camera Watec to the Arduino to get configured by the GPS data;

However, we try to replace our work by a mini prototype based on Arduino and GPS module, to represent the concept of a Video Time Inserter.

III.4 Realization a mini prototype of VTI Box:

In this montage we will replace the OSD Video shield by a TFT screen and we will add a camera module for Arduino, for that our work compose by two parts hardware and software

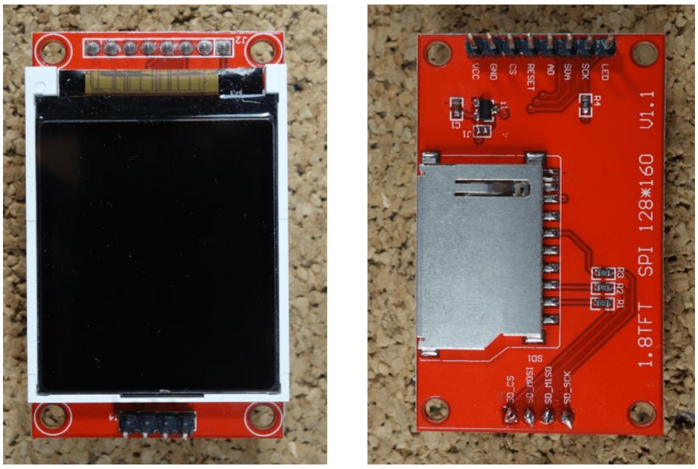
III.4.1: Hardwar part:

Contain the different components used in the montage, so at first we will define the materials we used

III.4.1.1: the main components

III.4.1.1.1 TFT screen:

The TFT screen is a type of LCD with a thin film transistor attached to each pixel. All computer LCD screens are TFT since early 2000s; older ones had slower response times and poorer color.



FigureIII.5: TFT screen

III.4.1.1.2: The OV7670 Camera:

is a low-cost image sensor and has an array image can operate at a maximum of 30 fps and 640 x 480 ('VGA') resolution, equivalent to 0.3 Megapixels. The captured image can be pre-processed by the DSP before sending it out. This preprocessing can be configured via the Serial Camera Control Bus (SCCB).

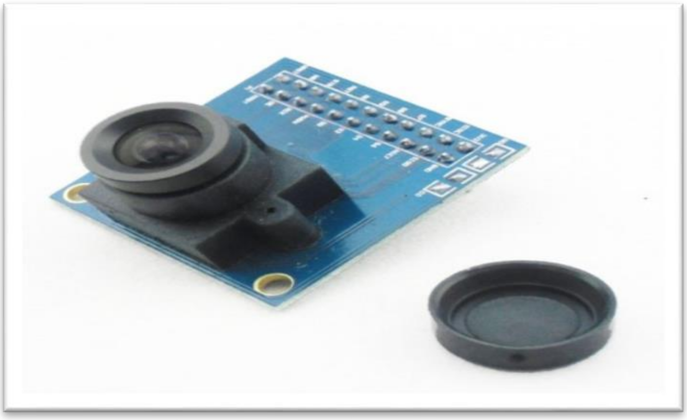


Figure III-6: Camera OV767

III.4.1.2 Assemblage the first part (TFT screen & GPS):

In this part we will wire the "1.8 inches" TFT screen or 4.5 centimeters and a GPS module with an Arduino circuit to display our data in the screen and for ensure our GPS module work correctly.

By using the jumpers and resistors (4×1 kΩ, 1×150Ω, 1×4.7 kΩ, 1×10 kΩ) we bring all the components together following the schema below

We wire our components according to the table below:

1.8 TFT Display	Wiring to Arduino Uno
LED	3.3 V
SCK	13
SDK	11
DC	9
RESET	8
CS	10
GND	GND
VCC	5 V

Table III-1: Represent link of pins between TFT and Arduino

GPS NEO6-M	Wiring to Arduino Uno
RX	TX
TX	RX
GND	GND
VCC	5 V

Table III-2: Represent link of pins between GPS and Arduino

III.4.1.2.1 Montage (1):

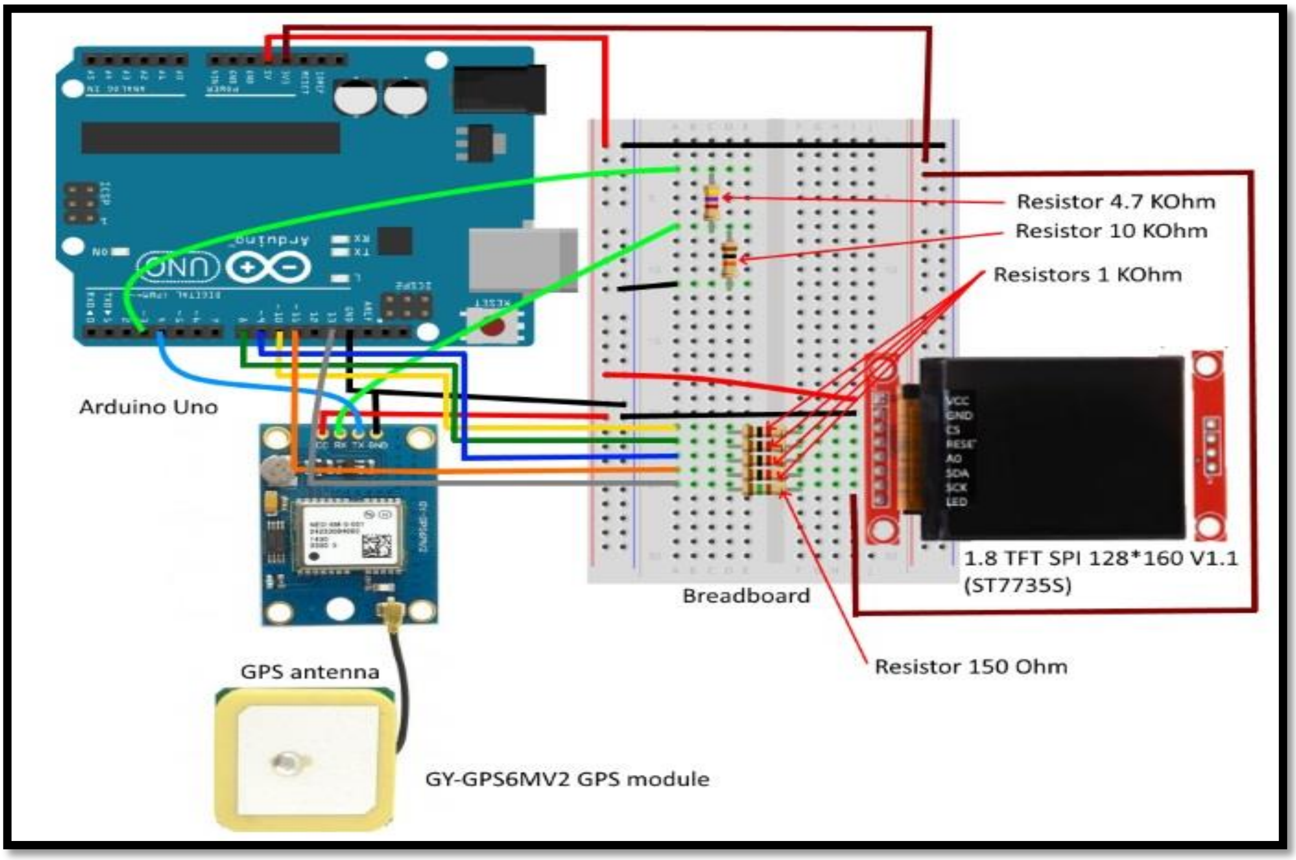


Figure III-7: Represent the circuit of TFT and GPS module

III.4.1.3 Assemblage the second part (Camera OV7670 & TFT screen):

In this part we will try to configurate the OV7670 Camera with Arduino and display the data in a TFT screen using the previous montage of the TFT screen, and for this montage we need as usual jumpers (female) and resistors (2×10 kΩ1×1 kΩ, 1×680 Ω)

OV7670	ARDUINO UNO
GND	GND
PWDN	GND
SIOD	A4
XCLK	D3
3.3V	3.3V
SIOC	A5
VSYNC	D2
PCLK	D12
RESET	3.3V

TableIII-3: wiring the camera pins

OV7670	ARD
D6	D6
D4	D4
D2	A2
D0	A0
D7	D7
D5	D5
D3	A3
D1	A1

Table III-4: wiring of the camera data pins

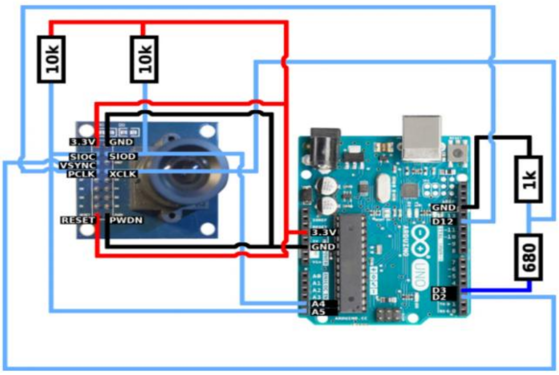


Figure III-8: wiring the camera pins with Arduino

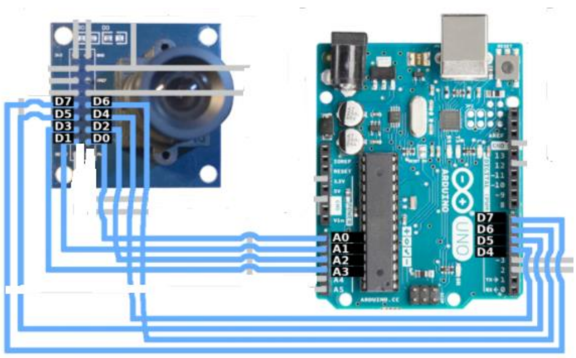
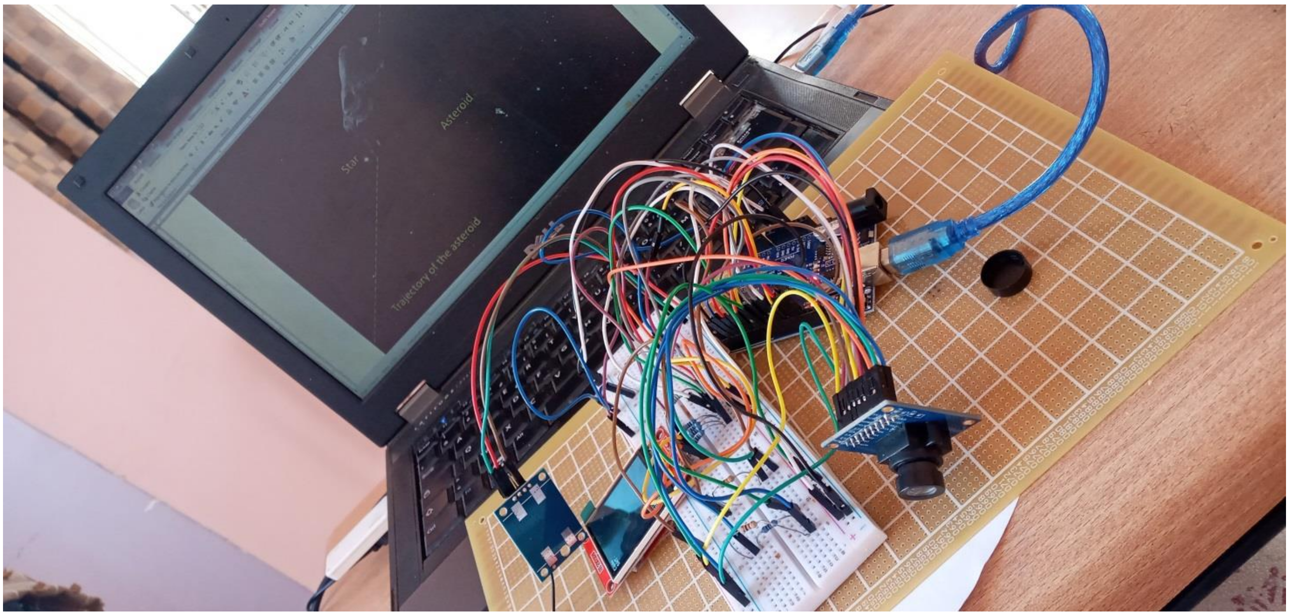


Figure III-9: wiring of the camera data pins with Arduin

III.4.1.4 The final montage:

By coupled the two previous montage into one circuit we will achieve the last montage as it shown in the figure 10



FigureIII-10: The final montage

III.4.2 Software parts:

The software part helps us to configure the hardware part and to manage our work. In our realization we use two different type of software, once specially for Arduino projects called Arduino IDE and the other a compilation software provide some packages allows to create a program to send the data from Arduino board into a computer by its serial

III.4.2.1 Arduino IDE:

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

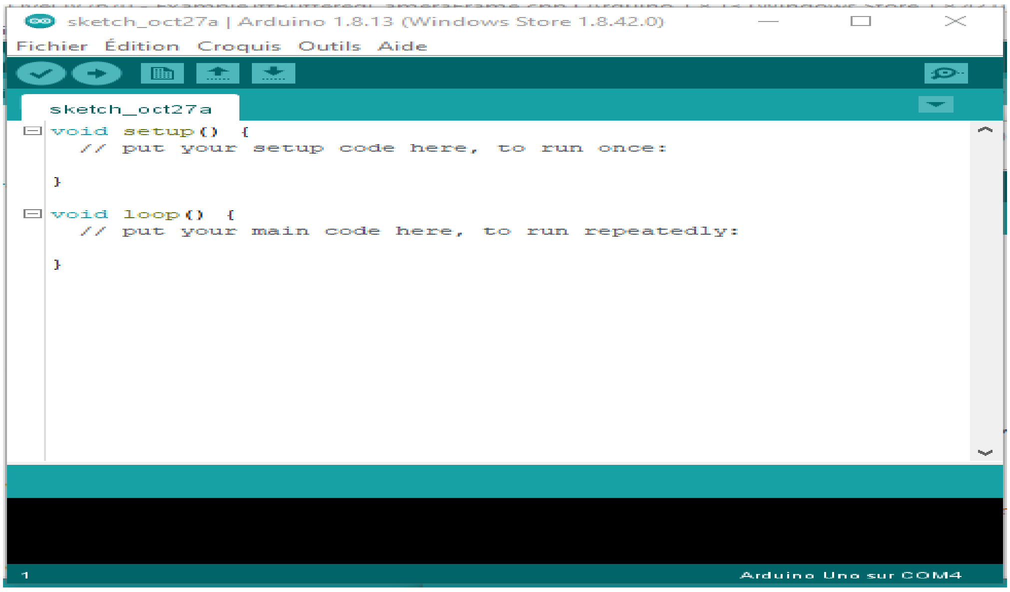


Figure III-11: Arduino IDE software

III.4.2.2 IntelliJ Idea:

IntelliJ is one of the most powerful and popular Integrated Development Environments (IDE) for Java. It is developed and maintained by JetBrains and available as community and ultimate edition. This feature rich IDE enables rapid development and helps in improving code quality. IntelliJ IDEA really understands and has a deep insight into your code, as well as the context of the coder, which makes it so unique among other Java IDEs [11]

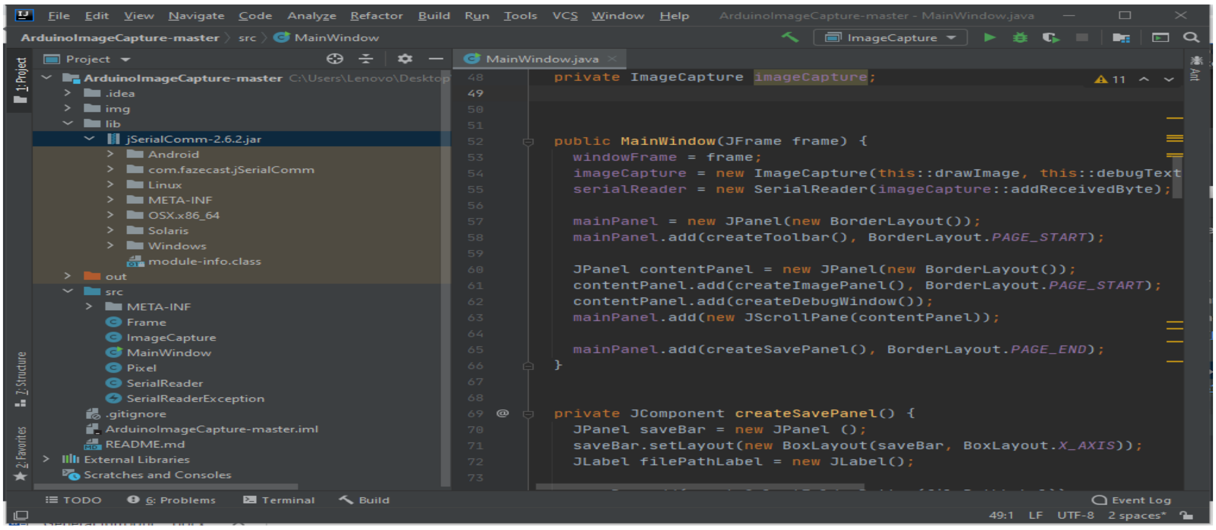


Figure III -12: IntelliJ Idea software

III.4.2.3 Configure the final montage with Arduino IDE:

III.4.2.3.1 TFT screen and GPS module:

We use for implemented their program libraries to made our work ore easy and encoded the data from GPS receiver and method of communication with Arduino board

- ***<u>TinyGPS++:</u>***

TinyGPS, this library provides compact and easy-to-use methods for extracting position, date, time, altitude, speed, and course from consumer GPS devices.

However, TinyGPS++'s programmer interface is considerably simpler to use than TinyGPS, and the new library can extract arbitrary data from any of the myriad NMEA sentences out there, even proprietary ones.

- ***<u>SPI (Serial Peripheral Interfaces):</u>***

Serial Peripheral Interface (SPI) is an interface bus commonly used to send data between microcontrollers and small peripherals such as shift registers, sensor.

With an SPI connection there is always one master device (usually a microcontroller) which controls the peripheral devices. Typically, there are three lines common to all the devices:

MISO (Master In Slave Out) - The Slave line for sending data to the master,

MOSI (Master Out Slave In) - The Master line for sending data to the peripherals,

SCK (Serial Clock) - The clock pulses which synchronize data transmission generated by the master

and one line specific for every device called **SS (Slave Select) -** the pin on each device that the master can use to enable and disable specific devices.

III.4.2.3.2 Camera module OV7670:

For initializes the video or the sequence frame captured by OV7670 module we should to insert a library for the video resolution and method for communication with Arduino.

- ***<u>I2C communication protocol:</u>***

The term IIC stands for "**Inter Integrated Circuits**". I2C is a synchronous communication protocol meaning, both the devices that are sharing the information must share a common clock signal. It has only two wires to share information out of which one is used for the cock signal and the other is used for sending and receiving data.

These two wires will be connected across two devices. Here one device is called a **master** and the other device is called as **slave**. Communication should and will always occur between two a **Master and a Slave**. The advantage of I2C communication is that more than one slave can be connected to a Master.

Serial Clock (SCL): Shares the clock signal generated by the master with the slave

Serial Data (SDA): Sends the data to and from between the Master and slave.

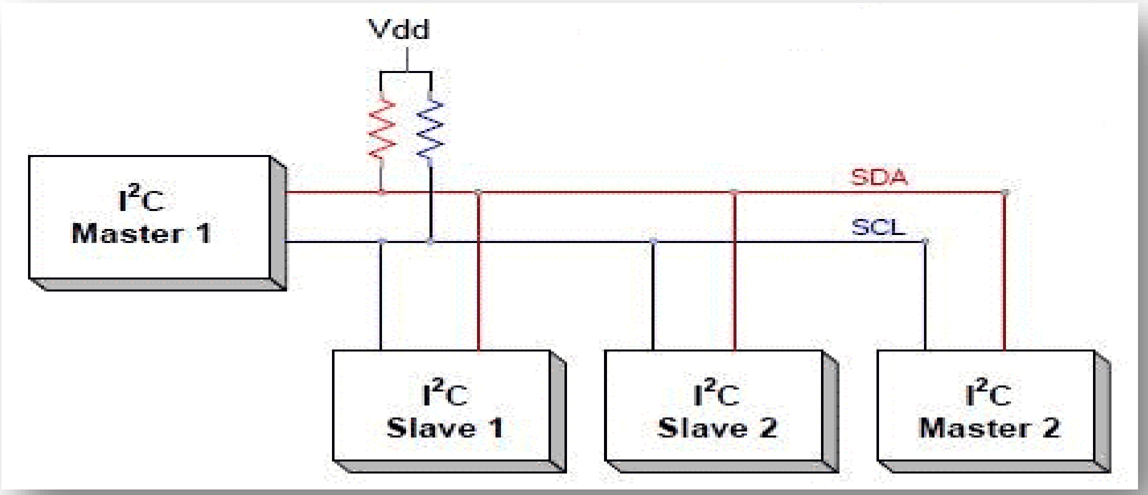


Figure III-13: Typical I²C Bus

Since OV7670 runs on I2C interface, it includes <util/twi.h> library.

- ❖ This function is used to get the image resolution size:

```
captureImg(160, 128);
```

- ❖ The camera is set to take a QVGA image so the resolution needs to be selected. The function configures the register to take a QVGA image.

```
setResolution();
```

III.4.2.4 Configure the final montage with InteliJ Idea:

For display our video time inserter on the computer we need a software that could to transfer the data by serial to save it. Hence, we use a code form GitHub platform on intelliJ Idea software developed by java.

- ***jSerialComm***

jSerialComm is a Java library designed to provide a platform-independent way to access standard serial ports without requiring external libraries, native code, or any other tools. It is meant as an alternative to Rx Tx and the (deprecated) Java Communications API, with increased ease-of-use, an enhanced support for timeouts, and the ability to open multiple ports simultaneously [12]

N.B: The code was created by Indrek Luuk on Github platform [11]

III.4.3 Results and discussion:

By powering the last montage we could see as a results

III.4.3.1 On real:

We observe a video display on a TFT screen injected by GPS data which was:

1. A sequence of frame or like we called a video with 10 Hz (we can augment the fps as we like)
2. Information obtained from the GPS module:
   - UTC Time: displaying in format (hh:mm:ss:ms)
   - E3.455437: represent the Longitude of our location 3 deg 455437'
   - N36.758686: represent the Latitude of our location 36 deg 758686'

Figure III-14: The video inserted by GPS time and data displaying on TFT screen

III.4.3.1 On computer:

When we execute the code on our software (IntelliJ Idea) the video obtained will transfer from the TFT screen into the computer, as a results we can watch and record in the same time the video on a folder chosen as a sequences of frame.

III.5 Conclusion:

In the end, we could realize a mini prototype that provide a video inserted by GPS precise time and data. In addition, we saved the results obtained easily by transfer the results by serial into the computer.

By this realization, we could to facilitate the work by eliminate the using of a converter analog degital and upgrade the perfermance.

General conclusion:

By using several telescopes each coupled to a CCD camera and a Video Time inserter that provide a precise time and location enable us to extract the contours and the shape of the asteroids. In fact, the study of these small bodies is important for understanding the birth and evolution of our solar system.

The aim of this master memory is the study and realize a prototype of a Video Time Inserter based on Arduino circuit coupled by a GPS module, which gives and introduces a precise date for each frame of a video obtained. This electronic circuit is used to measure the time of disappearance and reappearance of an occulted star by an asteroid.

At the beginning of our research, we focused on the understanding of transient astronomical phenomena, in this case, asteroids and stellar occultation by asteroids. And tried to define the observation concept and the tool we use it to get a proper operation.

Second, we explain the general concept of a GNSS and a GPS system and how it works passing to the VTI's different type. Then we manipulate how the IOAT VTI box is functioned to be aware about the path we should follow

Third, we realize a mini prototype of the VTI box based on the Arduino board and GPS module, TFT screen, OV7670 camera module. finally, we assemblage the final montage and according to our testing, we seen a video inserted by GPS timing data displaying on the TFT screen just by alimented the circuit and we could also transferred this video to a computer to be stored in a file Intended for this purpose.

Therefore, by this realization we achieve our goal by help to produce a chip version of a VTI box to available and facilitate the work of the astronomers in our country which absolutely their results help internationally.

In perspective, it is interesting to collect the frame storage in the computer by a specify application to get in the end a full video time inserter for easiest the treated will be done later.

REFERENCES

[1] Raymond Dusser, Jean Schwaenen et Roland Boninsegnalors. Les occultations d'étoiles par astéroïdes, http://www.astrosurf.com, Bruxelles.

[2]Xavier Demeersman, the sciences of the universe with a more pronounced interest in astronomy Journalist, www.futura-sciences.com, published on 27/03/2014.

[2] www.euraster.net

[3] https://www.minorplanetcenter.net/iau/mpc.html

[4] https://ui.adsabs.harvard.edu/abs/2011AGUFM.P23C1731C/abstract

[5] https://ui.adsabs.harvard.edu/abs/2019MNRAS.484.3765W/abstract

[6]www.asteroidoccultation.com

[7] Jean-Luc, global position système principes généraux de la localisation par satellite, consentie avril 2003.

[8] kb.meinbergglobal.com/kb/time_sync/ntp/configuration/ntp_nema_operation.

[9] http://www.lunar-occultations.com/iota/iotandx.htm

[10] Tony Barry, Dave Gault, IOTA-VTI v3.01, A GPS based video time.

[11] https://www.jetbrains.com/idea/

[12] https://fazecast.github.io/jSerialComm/

[13] https://github.com/indrekluuk/ArduinoImageCapture

Webography:

https://github.com/ 2020/10/25

www.eyrolles.com

https://www.futura-sciences.com 2020/09/4

/http://etudeselectroniques.free2020/06/10

http://astronomylinks.com/ 2020/09/04

http://visualgps.net/index.html 2020/10/08

http://www.asteroidoccultation.com/observations/ 2020/09/20

http://www.dangl.at/ausruest/vid_tim/vid_tim1.htm 2020/09/26

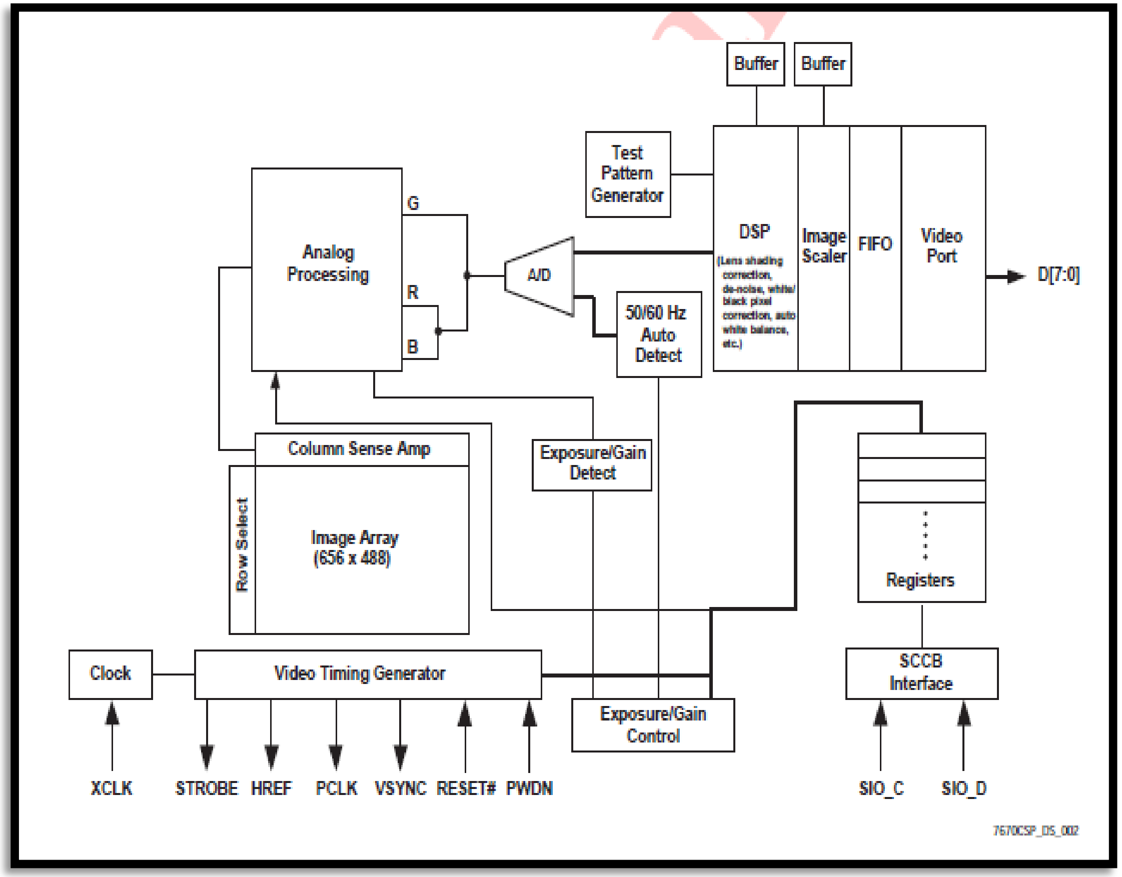
https://circuitdigest.com/2020/10/15

https://electronics.stackexchange.com/2020/10/20

Annex A: OV7670 Camera

Active Array Size		640 x 480
Power Supply	Digital Core	1.8VDC ±10%
	Analog	2.45V to 3.0V
	I/O	1.7V to 3.0V[a]
Power Requirements	Active	60 mW typical (15fps VGA YUV format)
	Standby	< 20 µA
Temperature Range	Operation	-30°C to 70°C
	Stable Image	0°C to 50°C
Output Formats (8-bit)		• YUV/YCbCr 4:2:2 • RGB565/555/444 • GRB 4:2:2 • Raw RGB Data
Lens Size		1/6"
Chief Ray Angle		25°
Maximum Image Transfer Rate		30 fps for VGA
Sensitivity		1.3 V/(Lux • sec)
S/N Ratio		46 dB
Dynamic Range		52 dB
Scan Mode		Progressive
Electronics Exposure		Up to 510:1 (for selected fps)
Pixel Size		3.6 µm x 3.6 µm
Dark Current		12 mV/s at 60°C
Well Capacity		17 K e
Image Area		2.36 mm x 1.76 mm
Package Dimensions		3785 µm x 4235 µm

Key specification



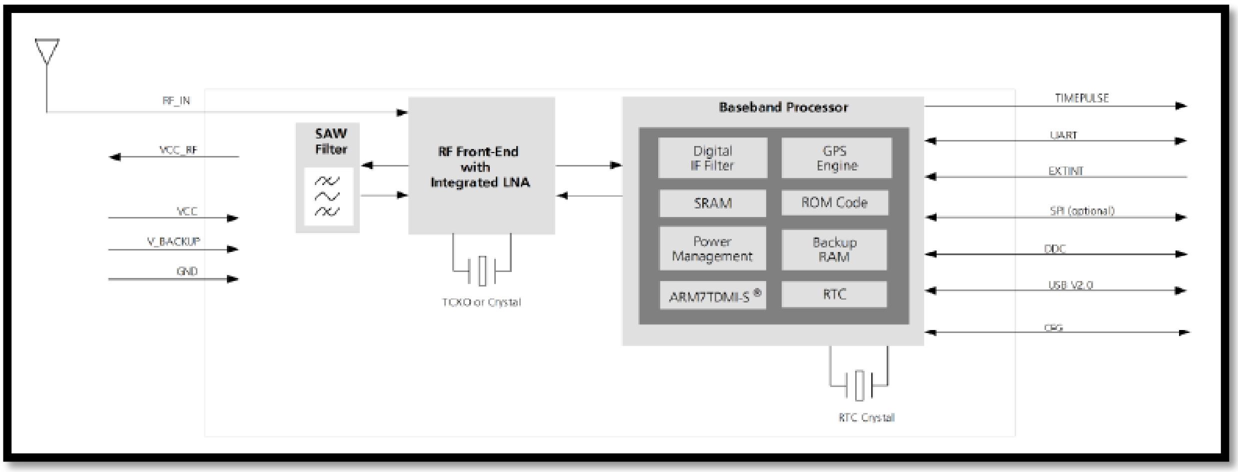
Block diagram

Pin Number	Name	Pin Type	Function/Description
A1	AVDD	Power	Analog power supply
A2	SIO_D	I/O	SCCB serial interface data I/O
A3	SIO_C	Input	SCCB serial interface clock input
A4	D1[a]	Output	YUV/RGB video component output bit[1]
A5	D3	Output	YUV/RGB video component output bit[3]
B1	PWDN	Input (0)[b]	Power Down Mode Selection 0: Normal mode 1: Power down mode
B2	VREF2	Reference	Reference voltage - connect to ground using a 0.1 µF capacitor
B3	AGND	Power	Analog ground
B4	D0	Output	YUV/RGB video component output bit[0]
B5	D2	Output	YUV/RGB video component output bit[2]
C1	DVDD	Power	Power supply (+1.8 VDC) for digital logic core
C2	VREF1	Reference	Reference voltage - connect to ground using a 0.1 µF capacitor
D1	VSYNC	Output	Vertical sync output
D2	HREF	Output	HREF output
E1	PCLK	Output	Pixel clock output
E2	STROBE	Output	LED/strobe control output
E3	XCLK	Input	System clock input
E4	D7	Output	YUV/RGB video component output bit[7]
E5	D5	Output	YUV/RGB video component output bit[5]
F1	DOVDD	Power	Digital power supply for I/O (1.7V ~ 3.0V)
F2	RESET#	Input	Clears all registers and resets them to their default values. 0: Reset mode 1: Normal mode
F3	DOGND	Power	Digital ground
F4	D6	Output	YUV/RGB video component output bit[6]
F5	D4	Output	YUV/RGB video component output bit[4]

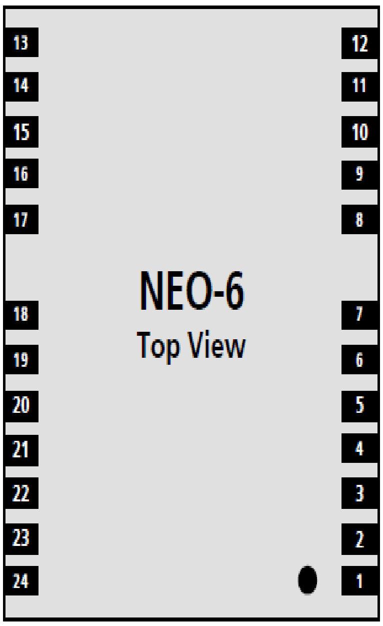
a. D[7:0] for 8-bit YUV or RGB (D[7] MSB, D[0] LSB)
b. Input (0) represents an internal pull-down resistor.

Pin description

Annex B: U-blox neo-6 GPS Modules



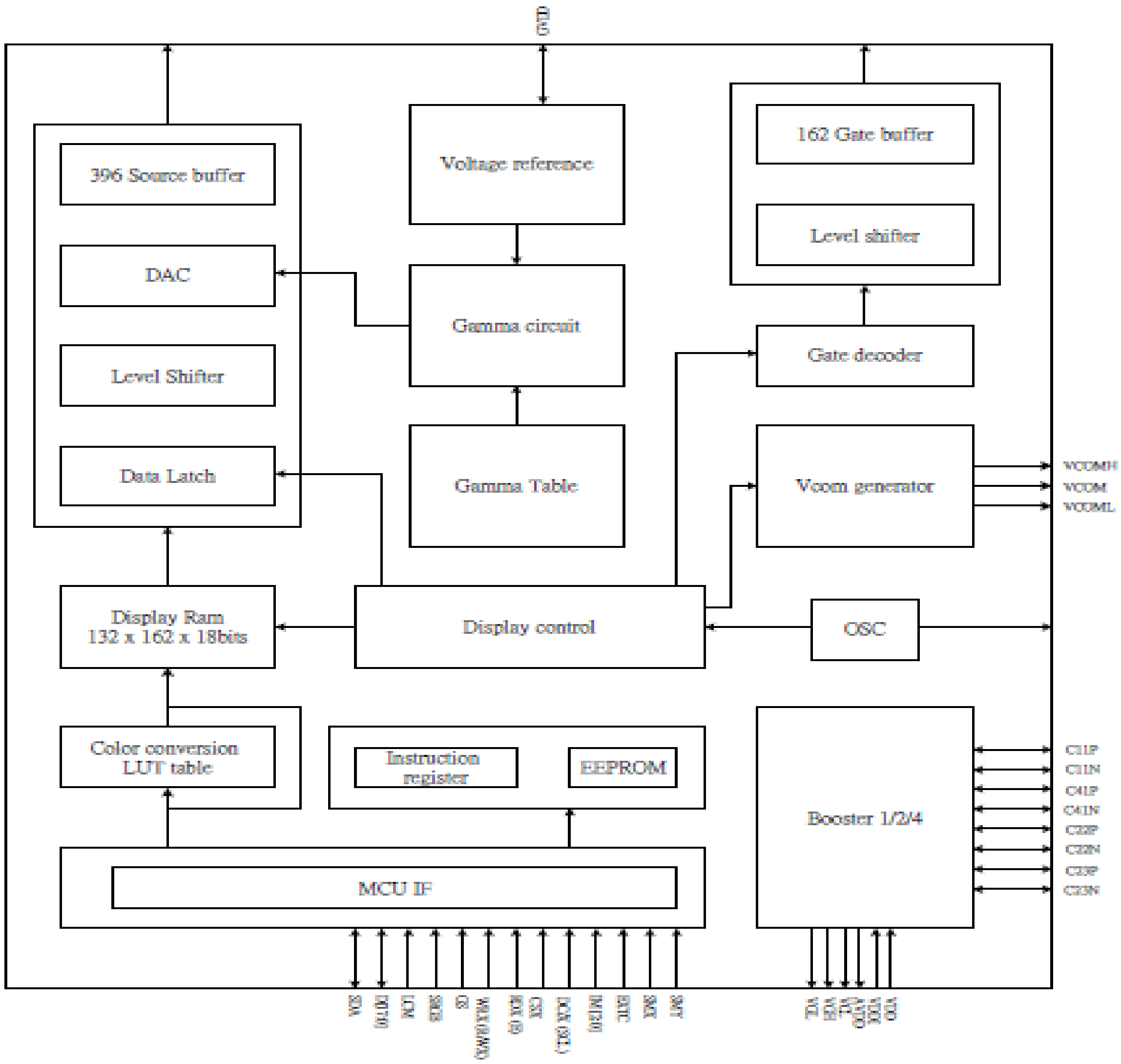
Block diagram



No	Module	Name	I/O	Description
1	All	Reserved	I	Reserved
2	All	SS_N	I	SPI Slave Select
3	All	TIMEPULSE	O	Timepulse (1PPS)
4	All	EXTINT0	I	External Interrupt Pin
5	All	USB_DM	I/O	USB Data
6	All	USB_DP	I/O	USB Data
7	All	VDDUSB	I	USB Supply
8	All	Reserved		See Hardware Integration Manual Pin 8 and 9 must be connected together.
9	All	VCC_RF	O	Output Voltage RF section Pin 8 and 9 must be connected together.
10	All	GND	I	Ground
11	All	RF_IN	I	GPS signal input
12	All	GND	I	Ground
13	All	GND	I	Ground
14	All	MOSI/CFG_COM0	O/I	SPI MOSI / Configuration Pin. Leave open if not used.
15	All	MISO/CFG_COM1	I	SPI MISO / Configuration Pin. Leave open if not used.
16	All	CFG_GPS0/SCK	I	Power Mode Configuration Pin / SPI Clock. Leave open if not used.
17	All	Reserved	I	Reserved
18	All	SDA2	I/O	DDC Data
19	All	SCL2	I/O	DDC Clock
20	All	TxD1	O	Serial Port 1
21	All	RxD1	I	Serial Port 1
22	All	V_BCKP	I	Backup voltage supply
23	All	VCC	I	Supply voltage
24	All	GND	I	Ground

Pin Definition

Annex C: ST7735 TFT screen



Block diagram