ECHO10P

Final Report

REVISION HISTORY AND APPROVAL RECORD

Revision	Date	Purpose
0	01/01/2015	Document creation
1	03/01/2015	Document revision
2	08/01/2015	Adding content
3	11/01/2015	Adding content
4	13/11/2015	Adding content
5	14/01/2015	Adding content
6	15/01/2015	Adding content, revision and close.

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0. CONTENTS

1. DOCUMENT SCOPE

The main goal of this document is to provide the information about the final specifications of the project, how the things had been done, how the work had been organized, developped and also the obtained achivements along the days following the time plan.

This document, is in main terms, a concise summary of the work completed. Therefore, it should include, on the one hand, a background about all the objectives that the project had in the beginning referring to the specifications of our product,the achievements we had in mind including the established organization to obtain it as well as the expected results, all summarized in the previous documents.

On the other hand, it should specify referring to the previous information provided, which of the aims have been accomplished, what went right or went wrong and whether the task were completed in time. Particularly, for every tasks we should specify the problems or inconvenients detected during the process, whether it could be resolved and how.

Apart of that, it should also include the lessons learned in the resolution of problems in projects and teamwork. Moreover, this documents contains and executive documentation about the system design, the implementation and characterization of the system and a brief explanation about the costs of the project.

Finally, during the project progress we have been detecting a variety of solutions, apart of the one we used and things that could have been done better both by the team members and the organization of it, so the recommendations for the future had to be expressed too in the document.

2. PROJECT SUMMARY

ECHO10P has been responsible for the development and implementation of a software-based product which creates a 3D model out of a traditional 2D ultrasound scanner, taking advantage of the features of image processing. This product arises from the need of providing a clearer image of the inside of the body when performing some procedures, specially for anesthesia-required operations or treatment of pain, in order to avoid injuring critical structures, such as muscles or veins. The final software is understood as a complement of the 2D ultrasound scanner and results in a very helpful tool for the work of medical professionals, since they will be able to explore the scanned area by pressing some buttons placed on the probe.

This project was born with the intention of making some research in the field of diagnose through image in order to come up with a new product able to help medical specialists in their diary tasks. It has been possible thanks to a collaboration agreement between Universitat Politècnica de Catalunya and IDIBELL, the research institute of Bellvitge's Hospital, one of the main medical centers in Catalonia.

The execution period of the project went from September 2014 from December 2014. As it is logic for such an extensive project, it needs a stage of research before starting the implementation, so it was decided that the resulting product would be a prototype of a possible further product. Furthermore, another aim of the work is to achieve a product significantly more economical than a 3D ultrasound scanner, which is the most similar alternative in the market nowadays.
As a result, the targets the team accomplished are the following:

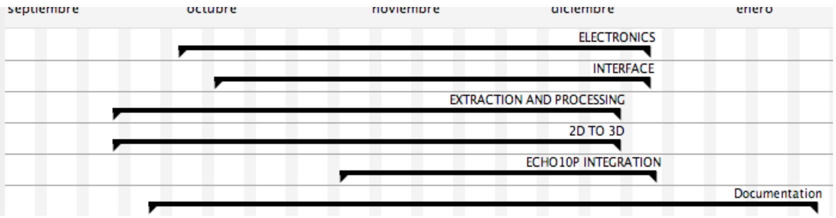
- Building of a 3D model out of a 2D ultrasound video.
- Integration of software and hardware to acquire position and display it on the user interface.
- Possibility of exploring the scanned zone with 5 buttons on the probe.

Nevertheless, as it has been explained, this is only a prototype of a future, more sophisticated product. So as to be more practical, some lines of action have been proposed in the fields of probe positioning and probe fastening. These suggestions are intended to act as guidelines for future implementations of the product.

3. TIME PLAN UPDATED

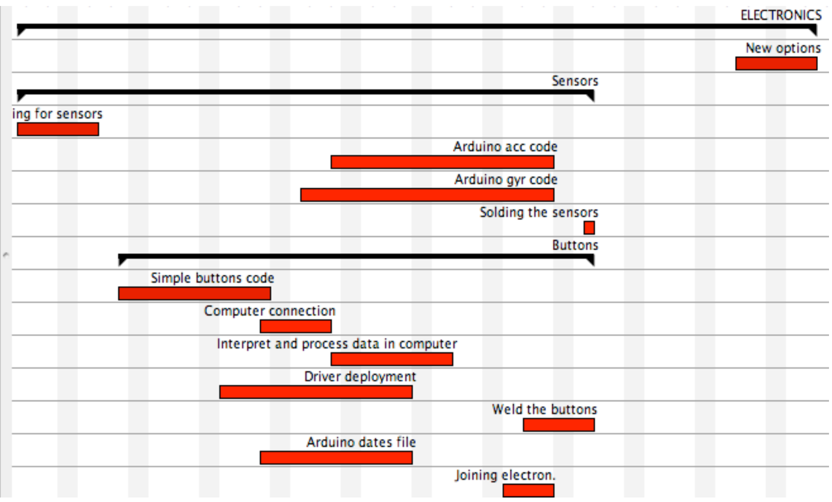
OVERVIEW TIME PLAN

Nombre	Fecha de...	Fecha de fin
ELECTRONICS	30/09/14	17/12/14
INTERFACE	6/10/14	17/12/14
EXTRACTION AND PROCESSING	19/09/14	12/12/14
2D TO 3D	19/09/14	12/12/14
ECHO10P INTEGRATION	27/10/14	18/12/14
Documentation	25/09/14	14/01/15



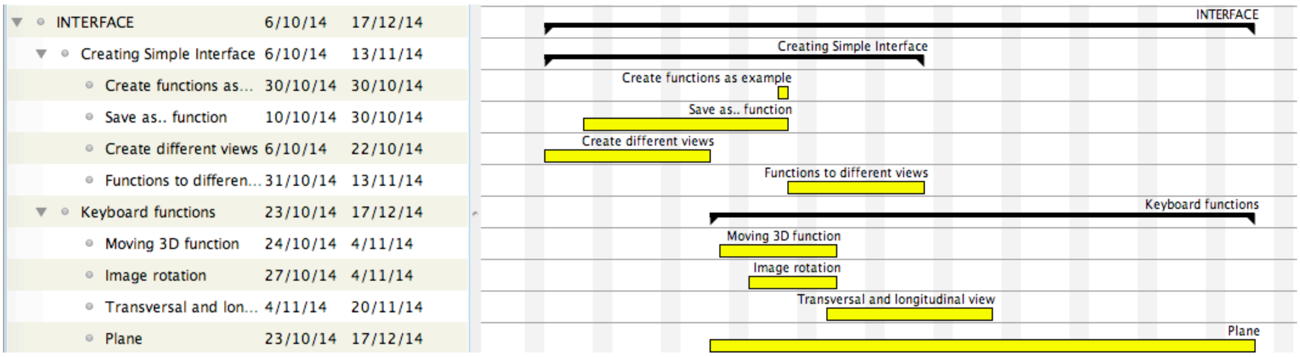
ELECTRONICS TIME PLAN.

ELECTRONICS	30/09/14	17/12/14
New options	10/12/14	17/12/14
Sensors	30/09/14	25/11/14
Looking for sensors	30/09/14	7/10/14
Arduino acc code	31/10/14	21/11/14
Arduino gyr code	28/10/14	21/11/14
Solding the sensors	25/11/14	25/11/14
Buttons	10/10/14	25/11/14
Simple buttons code	10/10/14	24/10/14
Computer connecti...	24/10/14	30/10/14
Interpret and proc...	31/10/14	11/11/14
Driver deployment	20/10/14	7/11/14
Weld the buttons	19/11/14	25/11/14
Arduino dates file	24/10/14	7/11/14
Joining electron.	17/11/14	21/11/14



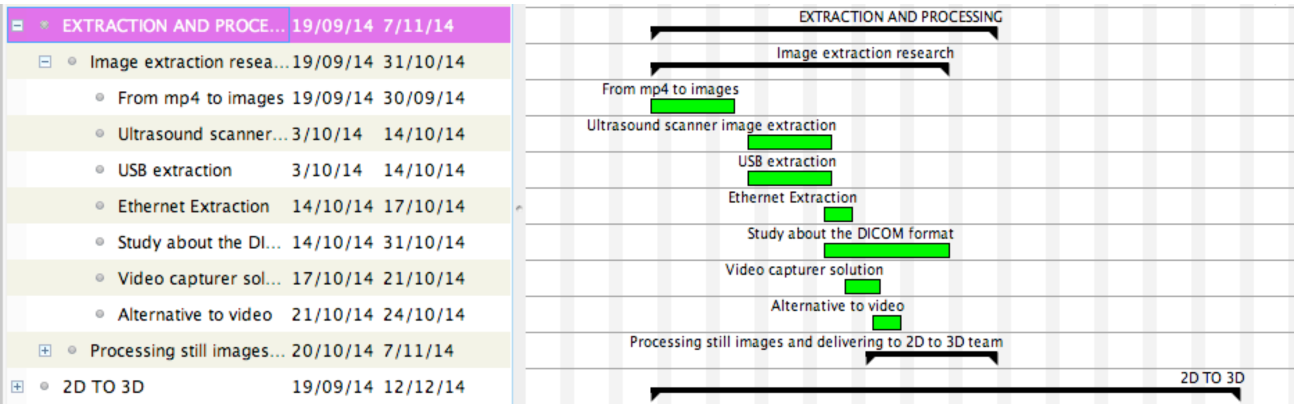
The main changes have been when the team has faced on that the option we have been working on had not the resolution we expected and had also thermal drifts. When we realized so was too late to begin to work in other options so we focused on looking for another choices as the probe support.

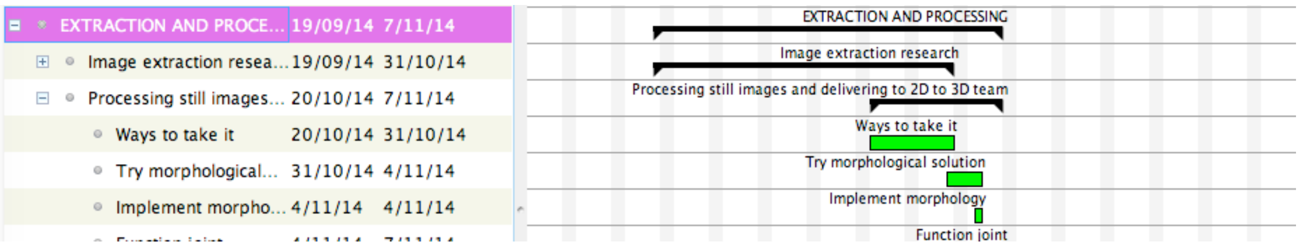
INTERFACE TIME PLAN.



The most important change of the time plan of Interface team has been the need of showing a plane in the 3D models. In order to make it useful and visible we have done many changes on the algorithms. As finally the client could choose between two different 3D models, we have changed the main page of the interface to give the client the capability of choosing the model and structures.

EXTRACTION AND PROCESSING TIME PLAN

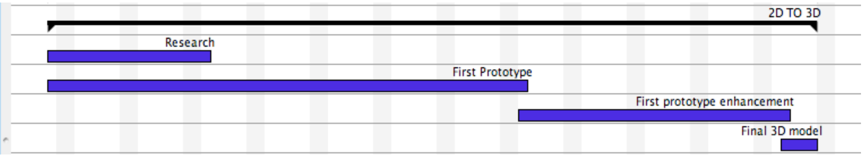




This time plan has not suffered some important changes. There have been some changes when it has been time to implement the processing to the interface, because of the processor time. Also, when the team has realized the true meaning of modelling a 3D they abandoned the idea of tissue detection.

2D TO 3D TIME PLAN

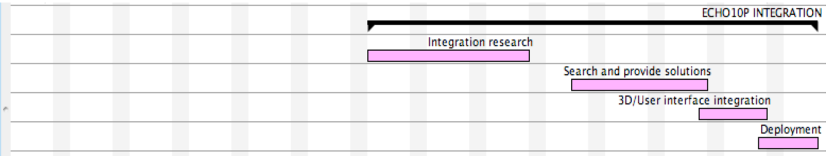
2D TO 3D	19/09/14	12/12/14
Research	19/09/14	6/10/14
First Prototype	19/09/14	10/11/14
First prototype enhance...	10/11/14	9/12/14
Final 3D model	9/12/14	12/12/14



The most important change in the 2D to 3D time plan has been when the team find out of another way of 3D modelling. After finding this new 3D model, the implementation was very fast and the algorithms were faster than the previous model too, so it did not change a lot the team time plan.

ECHO10P Integration TIME PLAN

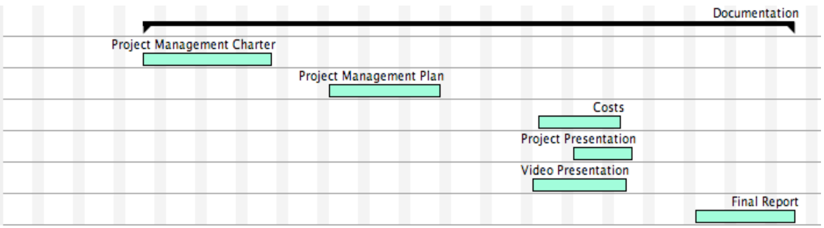
ECHO10P INTEGRATION	27/10/14	18/12/14
Integration research	27/10/14	14/11/14
Search and provide solu...	20/11/14	5/12/14
3D/User interface integr...	5/12/14	12/12/14
Deployment	12/12/14	18/12/14



The integration of the project has been as we expected.

DOCUMENTATION TIME PLAN

Documentation	25/09/14	14/01/15
Project Management Charter	25/09/14	16/10/14
Project Management Plan	27/10/14	14/11/14
Costs	2/12/14	15/12/14
Project Presentation	8/12/14	17/12/14
Video Presentation	1/12/14	16/12/14
Final Report	29/12/14	14/01/15

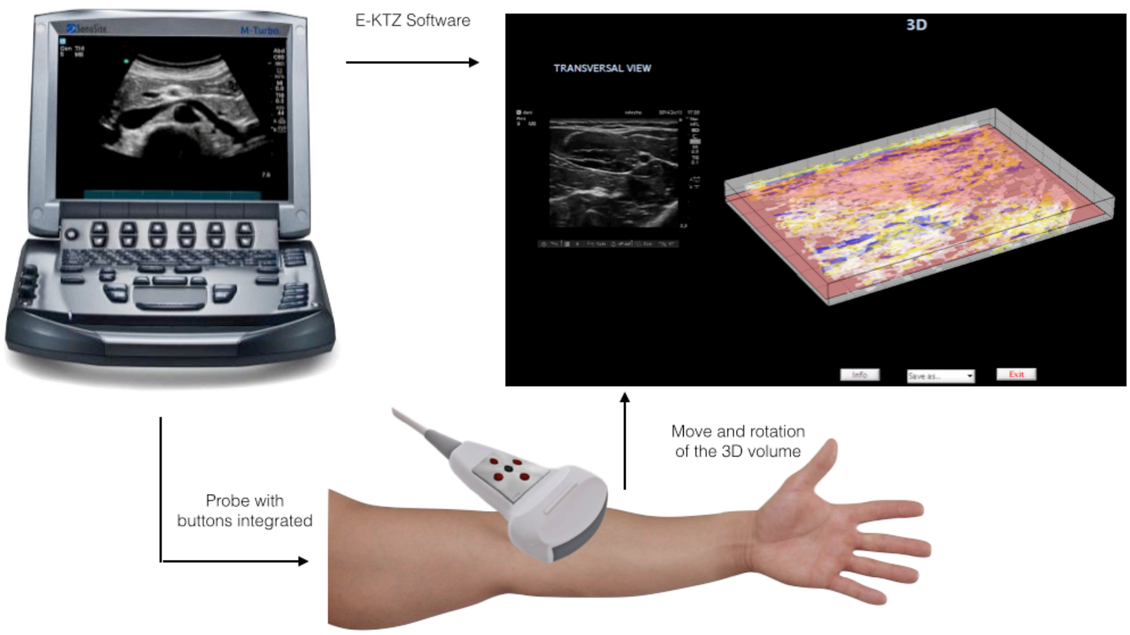


The documentation part of the project has taken more time than expected, specially preparing the Project Presentation and the Costs creating the video used in the final presentation. All the team have tried to make their work of the project as well as the documentation part.

4. SYSTEM DESIGN DOCUMENTATION

5.

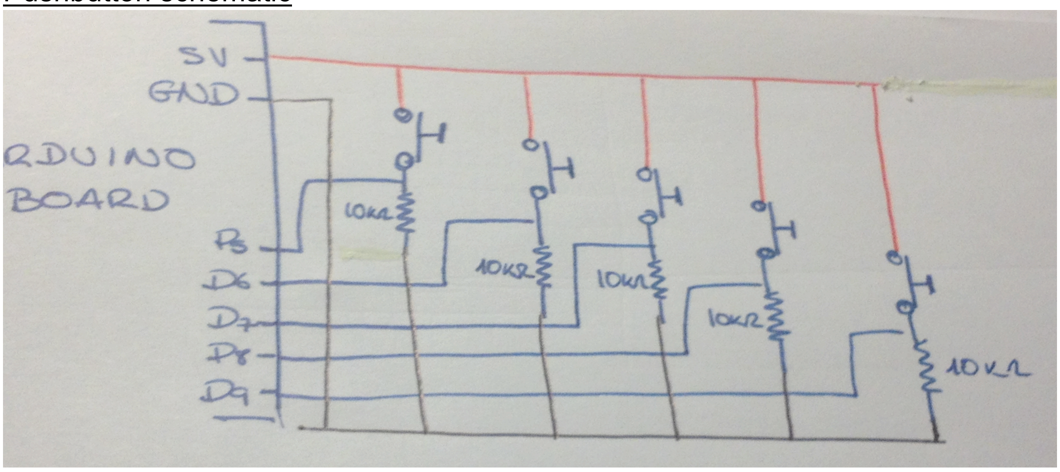
Block diagram



This diagram represents the relations and the connections between the different blocks of our project. The connection between the ultrasound scanner and the interface is made with software that transforms the images of the ultrasound scanner to a 3D model and represents the typical image of an ultrasound scanner too.
Then there is the probe, which is connected with the ultrasound scanner and with the interface and permits the user interact with the 3D model and give information about the position to the software.

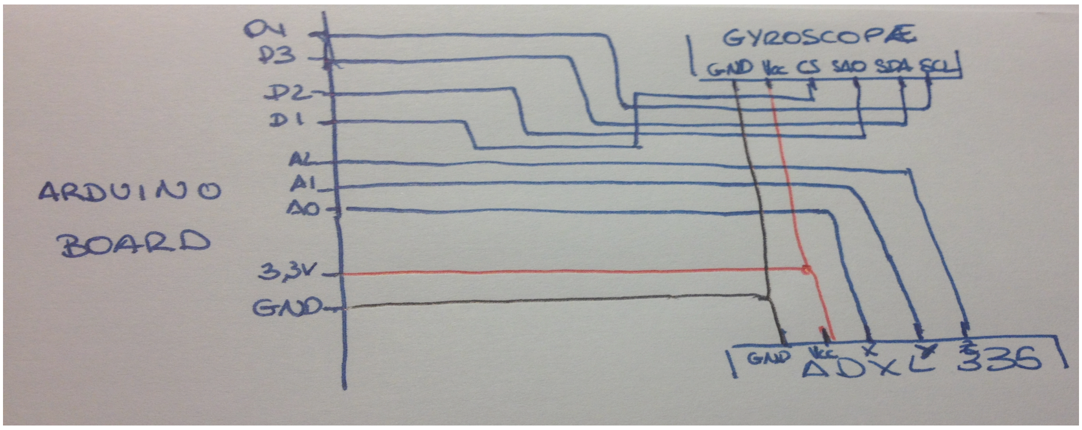
Initial schematics

Pushbutton schematic



This schematic represents the connections of the 5 pushbuttons with the Arduino. These pushbuttons permits the user interact with the 3D model and move it.

<u>Sensors schematic</u>

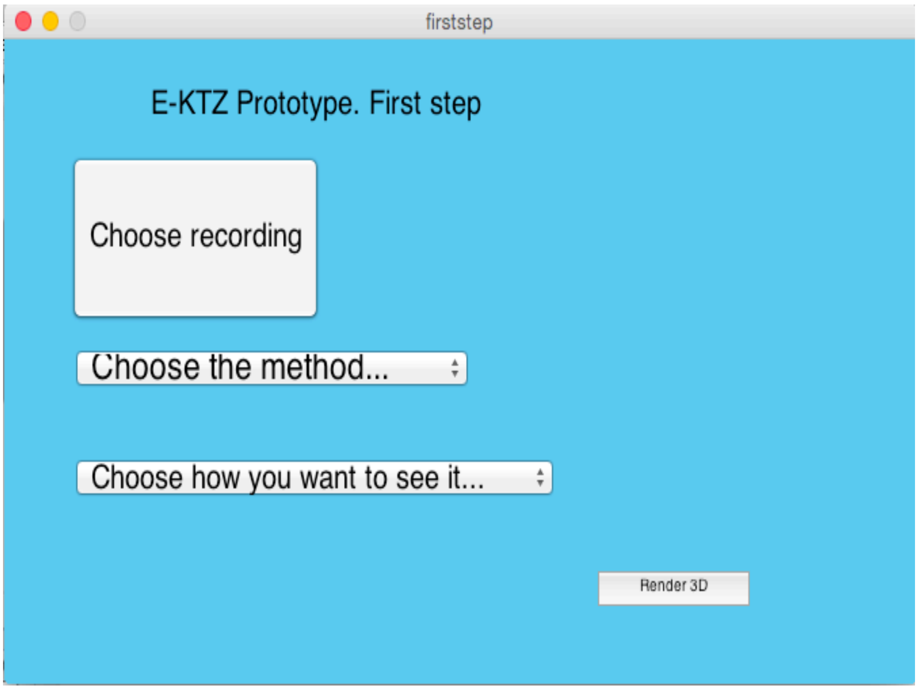


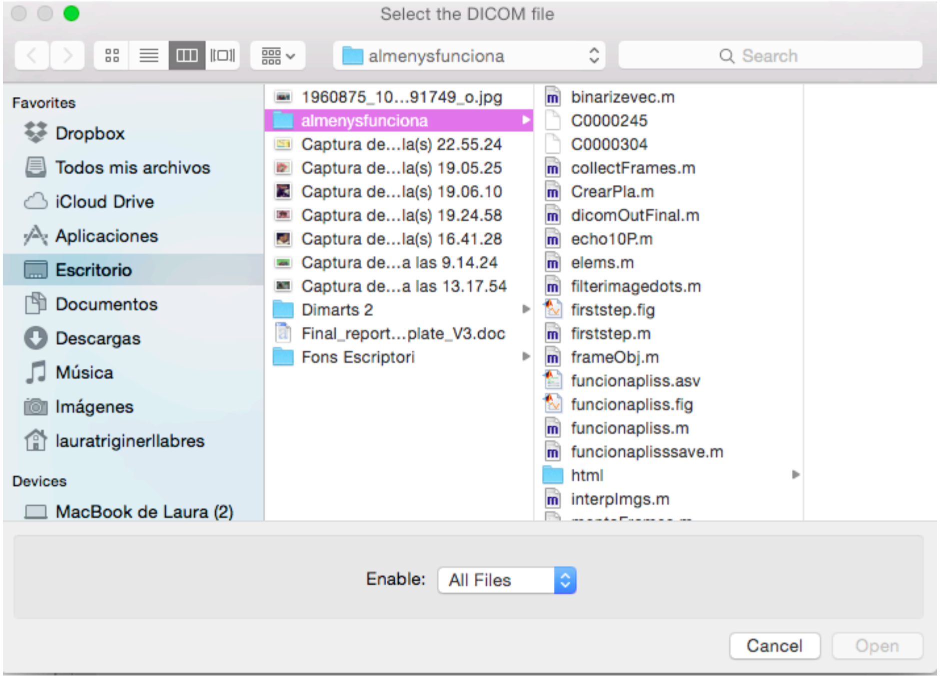
The schematic represents the connection between the Arduino and the sensors, which gives us the information about the position. This information will be send to the software to create the 3D model. The information will be in changed from m/s^2 and º/m to millimeters and degrees in the software.

Interface screenshots

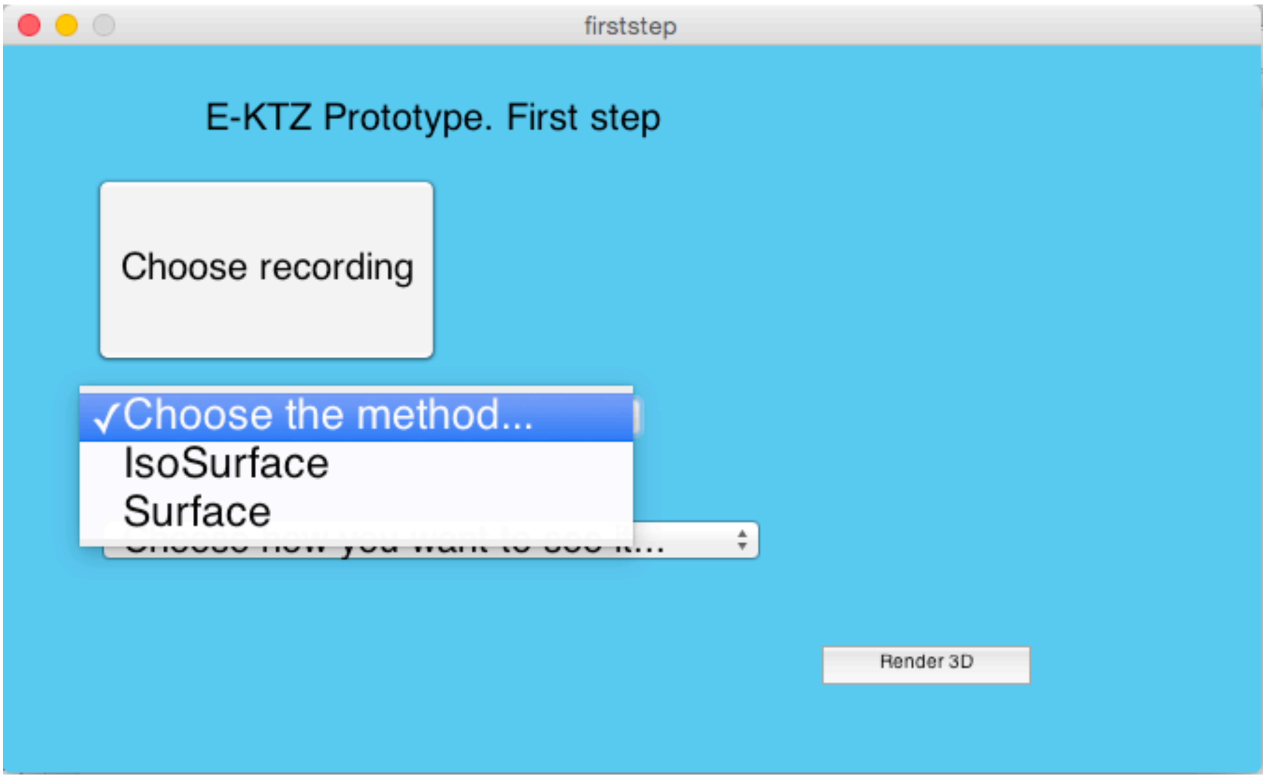
First Step screenshot

It's the main page, when the specialist is going to choose the DICOM file he wants to observe, the 3D model and how he wants to see it.

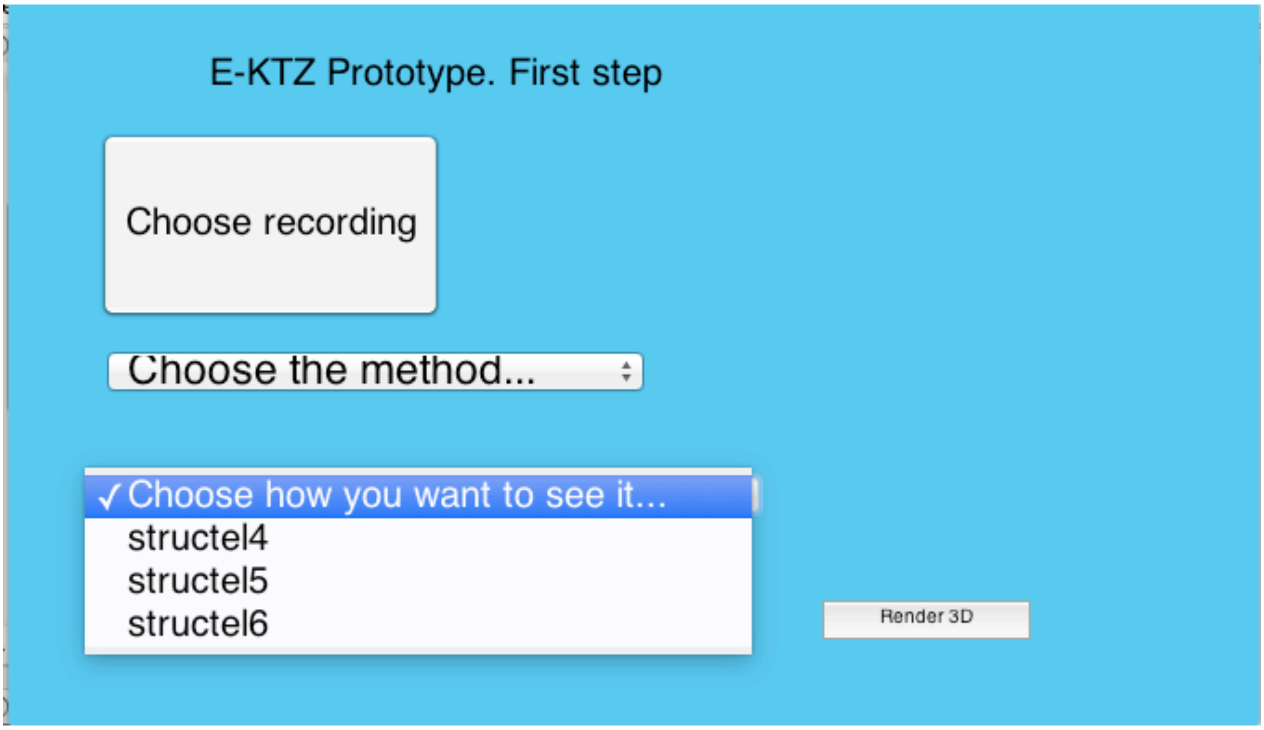




Select the DICOM file
almenysfunciona
Search
Favorites
Dropbox
Todos mis archivos
iCloud Drive
Aplicaciones
Escritorio
Documentos
Descargas
Música
Imágenes
lauratriginerllabres
Devices
MacBook de Laura (2)
1960875_10...91749_o.jpg
almenysfunciona
Captura de...la(s) 22.55.24
Captura de...la(s) 19.05.25
Captura de...la(s) 19.06.10
Captura de...la(s) 19.24.58
Captura de...la(s) 16.41.28
Captura de...a las 9.14.24
Captura de...a las 13.17.54
Dimarts 2
Final_report...plate_V3.doc
Fons Escriptori
binarizevec.m
C0000245
C0000304
collectFrames.m
CrearPla.m
dicomOutFinal.m
echo10P.m
elems.m
filterimagedots.m
firststep.fig
firststep.m
frameObj.m
funcionapliss.asv
funcionapliss.fig
funcionapliss.m
funcionaplisssave.m
html
interpImgs.m
Enable:
All Files
Cancel
Open

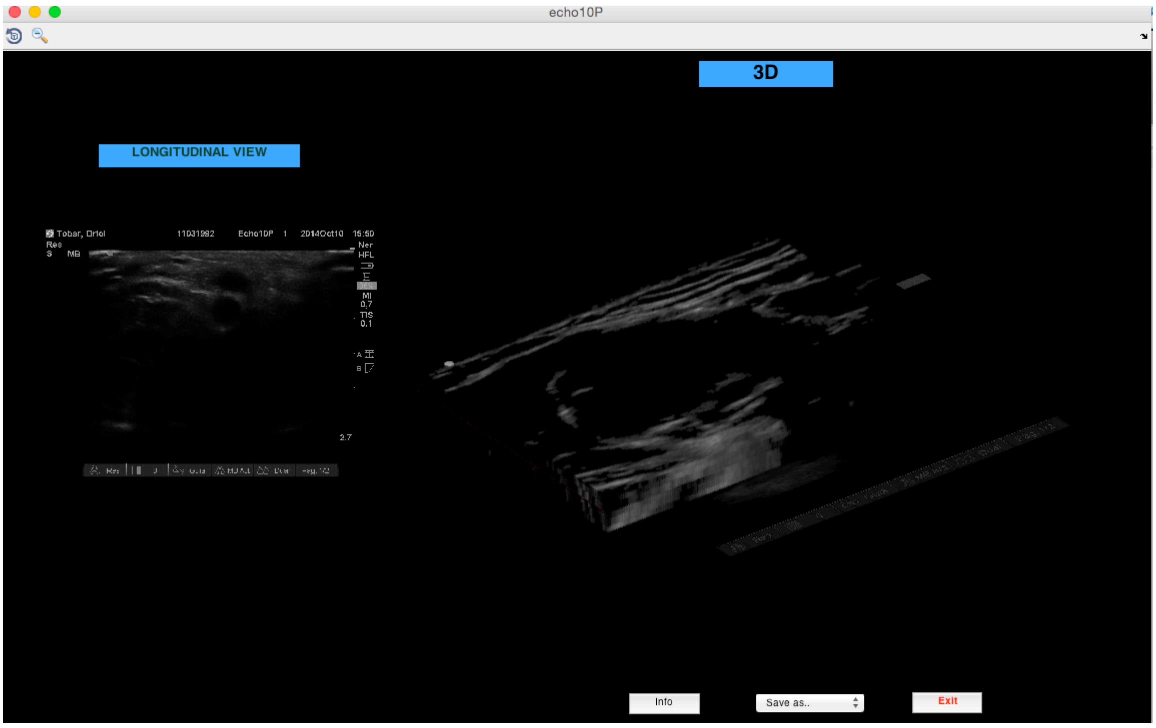


firststep
E-KTZ Prototype. First step
Choose recording
✓Choose the method...
IsoSurface
Surface
Render 3D

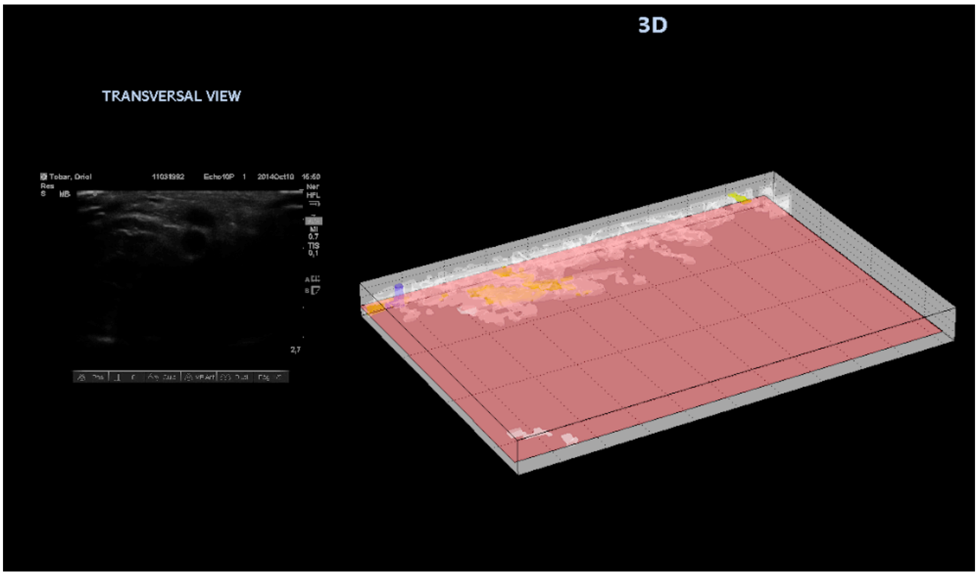


Second Step interface

When choosing the Surface model and pressing the 'up' button. This is what we are going to see...



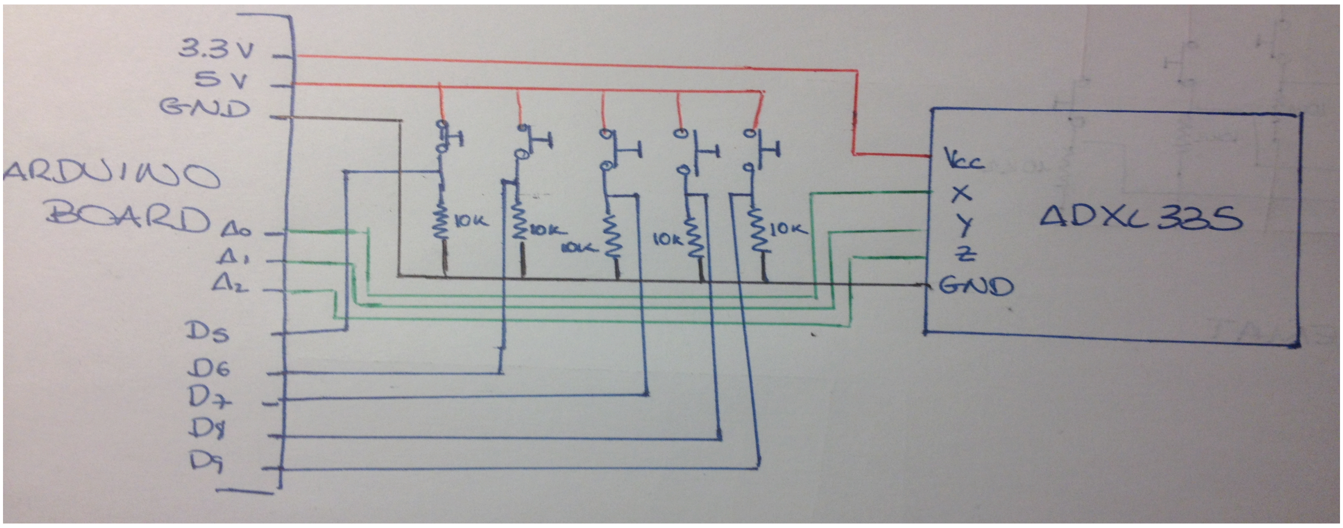
When choosing IsoSurface model



We can observe that there is a red plane in the model. This is because we have created a function that, given the probe position, is able to show in which part of the 3D model are you positioned and shows you the ultrasound image captured some minutes before.

6. SYSTEM IMPLEMENTATION DOCUMENTATION

Hardware FINAL Schematic



This schematic represents the final circuit. It includes the 5 pushbuttons and the accelerometer. The pushbuttons permit the user interacts with the interface, and the accelerometer gives information about the position. At the final schematic do not appear the gyroscope because with the final procedure of scanning is not necessary and we do not include it at the final prototype.

Components

- 5 pushbuttons
- 5 resistances of 10 kΩ
- Arduino Uno Board
- Accelerometer ADXL 335

Functions related to the block diagramm below:

Vidto3d: Returns the 3d model calculated from the video and the position files, the structuring elements and the number of iterations.

CollectFrames: Returns the frames of a DICOM video.

MontaFrames: Creates objects of the type "frameObj" from the frames and the positions.

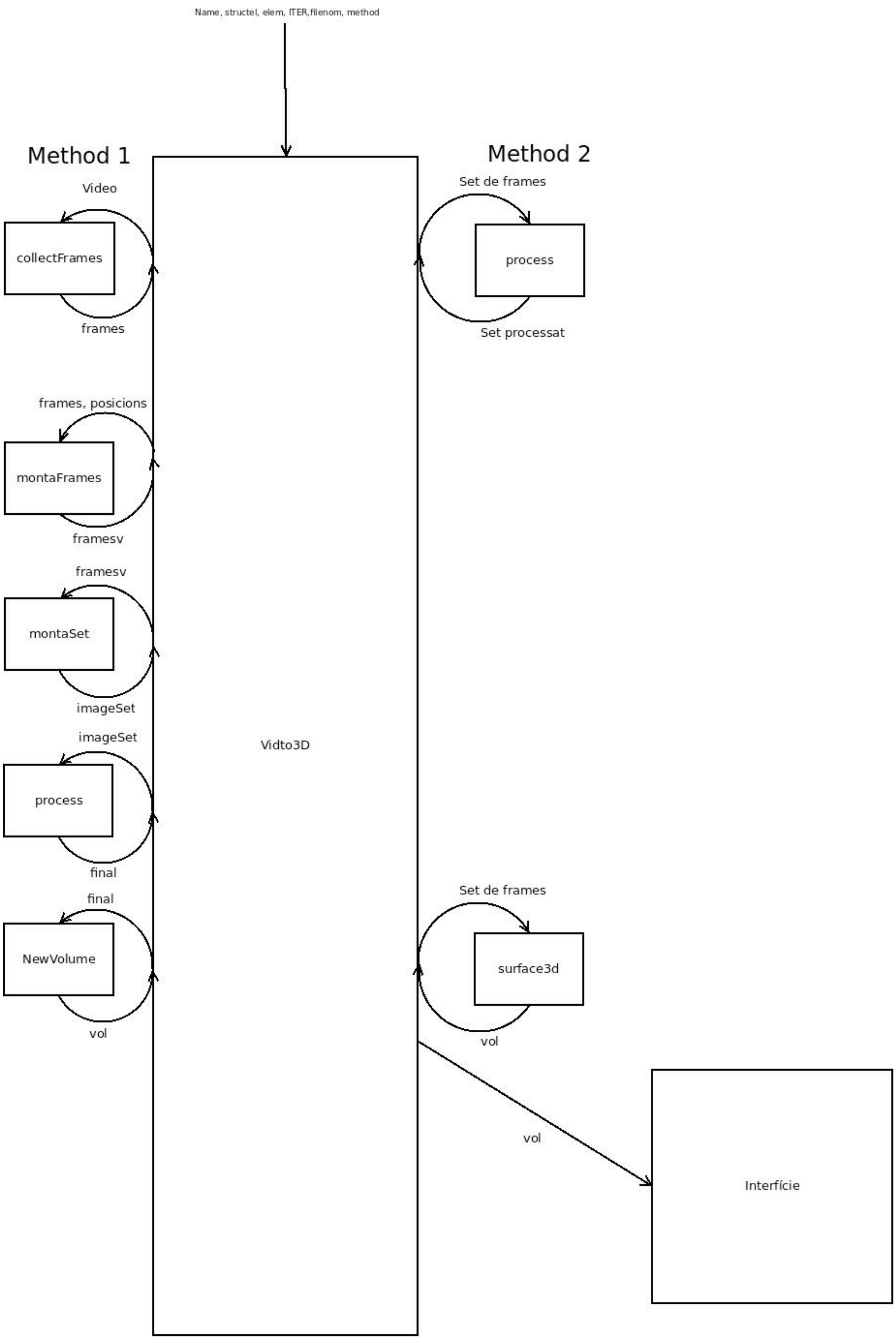
MontaSet: Discards invalid positions and interpolates images between gaps, returning a new set of images.

Process: Process the new set of images both spacially and temporally with the selected structuring elements, as many times as the chosen number of iterations.

Newvolume: Creates the volume from the new processed set of images, using the IsoSurface method.

Surface3d: Creates the volume from the new processed set of images, using the surface method.

Interfície: Shows the 3d model and allows interaction with it.



7. SYSTEM CHARACTERIZATION

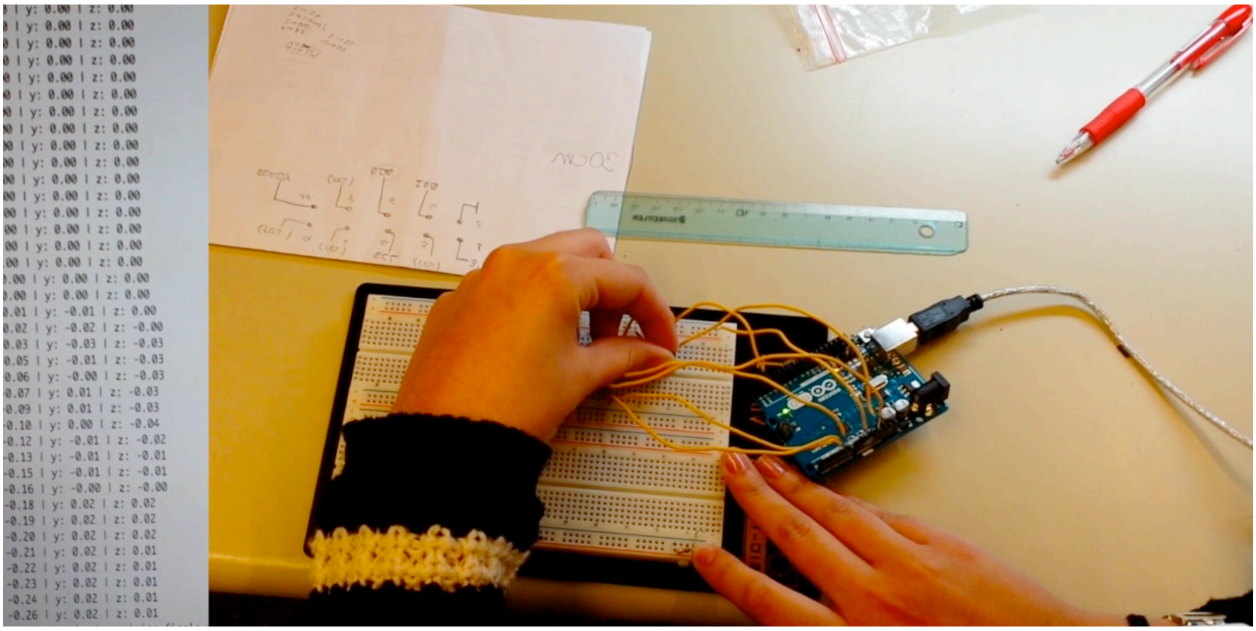
ELECTRONICS

Buttons:

To integrate the buttons we had to deal with two different parts. On the one hand, the code implementation was pretty easy to carry out. Once achieved, we integrated the 5 buttons to the arduino board and the accelerometer by welding it with all the elctronic components. Altogether was finally attached to the ultrasound probe.

Accelerometer :

The results obtained with this sensor are about 1 cm imprecise . In order to check the reliability of it, we did an experiment. It consisted on measure a knowing distance, exactly 30 cm. We placed the accelerometer at 0cm, and at the time we pressed the scan button, we started to move the sensor until we get at the 30 cm mark, when we pressed again the button to indicate that the end of the scan. The value given by the sensor should correspond to the 30cm, with an error range lower than 1cm.



INTERFACE

The interface is the way the specialist interact with the product, so we designed and intuitive menu to select the 3D model that the client want to use and a button that allows start the recording. After getting the model representation, we have added a rotation to the model in order to visualize better the figure.
Finally, we thought that it would be useful for the doctor to know in every moment where is the probe refered to the model. Even if we could not offer this facility due to the problems on the sensor, we created a plane over the model that allows visualize in the left of the screen, the transversal view of the selected point, useful for doctors since is the kind of image they are used to work with.

3D

The 3D model block was responsible for cleaning the images coming from the ultrasound scanner. With this block we expected to get good images to be stacked afterwards and create the final 3D model. However, we realised we could do the 3D model in two different ways. On the one hand, by using the isosurface we got a non clear 3D model which turned out to be very slow in terms of processing. For this reason, we looked on another method, the surface tool, which provided a faster (6x) and more resolutive processing.

CONCLUSION

The results obtained in all the blocks are satisfactory because they are basically what we expected to get. In reference to the accelerometer, we are conscious that the results could have been more precise if we had acquired a better one. A part from that, we consider the whole project to be reliable in a way that it provides precise information.

8. COSTS

Components list with their costs.

Gyroscope L3GD20 → 13.25 €
Accelerometer ADXL335 → 12.42 €
5 pushbuttons → 0.8 € each one
Arduino Uno Board → 12 €

Prototyping costs separate by main tasks and team members

NAME	TASK	TIME REQUIRED (hours)	COST (euros)
Pol Delgado	Initial project preparation	20	612
	Driver implementation	35	
	Components integration	20	
	Preparation for Bellvitge presentation	5	
	Final project integration	12	
	Research of information	10	
Jordi Hernan	Look for accurate sensors	35	1314
	Button code implementation	3	
	Accelerometer code implementation	30	
	Electronic welding	10	
	Gyroscope code implementation	20	
	Business costs documentation	35	
	Final report documentation	8	
	Look for new alternatives/solutions	15	
	Final project presentation	10	
	Hardware integration	40	
	3D ultrasound printing	1	
	Ultrasound probe prototype design	7	
	Box prototype design	4	
	3D box printing	1	
Alba Luján	Gyroscope code implementation	35	1020
	Accelerometer code implementation	15	
	Driver implementation	15	
	Components integration	10	
	Hardware integration	30	
	Mid-term presentation	5	
	Business costs documentation	35	
	Final report documentation	6	
	Final project integration	10	
	Project management plan	5	
	Project charter documentation	4	

Juan Martín	2D to 3D research	30	1254
	Development of the Matlab functions	60	
	First prototype enhancement	40	
	Final 3D model	20	
	Production of the video presentation	25	
	Ultrasound support design	30	
	Mid-term presentation	4	
Ignasi Mas	Mp4 to image conversion	20	1182
	Image extraction	28	
	USB extraction	16	
	Ethernet extraction	15	
	3D image enhancement	32	
	Morphology solutions	45	
	Implementation	25	
	Final report documentation	5	
	Final project presentation	8	
	Project management plan	3	
Joan Pallarès	Button code implementation	12	1080
	Accelerometer code implementation	30	
	Gyroscope code implementation	17	
	Hardware integration	15	
	Driver implementation	10	
	Components integration	12	
	Final report documentation	15	
	Final project presentation	10	
	Business costs documentation	35	
	Final project integration	8	
	Project management plan	12	
	Project charter documentation	4	
Francesc Pérez	Creating different views	10	1170
	Creating function as	8	
	Creating save as function	12	
	Enhance different views aspect	15	
	Image rotation	17	
	3D model movement	20	
	Plane	40	
	Transversal and longitudinal view	30	
	Business costs documentation	35	
	Final report documentation	3	
	Mid-term presentation	5	

Oriol Tobar	Final project presentation	20	1038
	Preparation for Bellvitge presentation	25	
	Final 3D model	10	
	2D to 3D research	30	
	First prototype enhancement	40	
	Development of the Matlab functions	40	
	Project management plan	4	
	Project charter documentation	4	
Laura Triginer	Creating different views	9	1338
	Creating function as	4	
	Creating save as function	8	
	Enhance different views aspect	10	
	Image rotation	12	
	3D model movement	24	
	Plane	40	
	Transversal and longitudinal view	35	
	Business costs documentation	45	
	Final report documentation	8	
	Final project presentation	5	
	General documentation tasks	17	
	Project charter documentation	6	
Dani Villaplana	Mp4 to image conversion	20	1014
	Image extraction	18	
	USB extraction	22	
	Ethernet extraction	15	
	DICOM format	30	
	Video capture	22	
	Alternative to video	12	
	Mid-term presentation	5	
	Ultrasound support design	15	
	Final project integration	10	

9. CONCLUSIONS

The final prototype fulfills the initial and most important condition: it creates a 3D model from a 2D video. We've managed to create a proper design that can be easily integrated to the probe and allows doctors to control the interface through the buttons - we've managed to create a driver that interconnects the software and the hardware. We reckon it is very easy to handle, specially because the system requires only one hand in order to work with it.

As far as the business model is concerned, we've envisaged a realistic and feasible proposal. In a 4 year term, we've proved that our business is economically powerful and profitable. This is due to the fact that our product turns out to be innovative in a way that it fulfills quality and price. Thus, we are convinced that hospitals will soon get in contact with us to acquire it. For them, anesthetists in particular, E-KTZ will mean modernizing, enhancing and empowering the anesthesia injecting process.

To conclude, we want to make clear that it's been a pleasure to work with Echo10P since there's been a lovely atmosphere between the team members. The organization has been crucial for the development of the project because thanks to that, we've managed to deliver the final product on time as the client required.

10. REFLECTION DOCUMENT

From the group, we believe that organizers, generally speaking, were helpful in a very positive way. They provided us with all the necessary information and theoretical aspects to carry out the project satisfyingly. However, when it came developing and working we were totally free to come up with new ideas and we were never forced to do what lecturers told us to do. We'd like to add, though, that for some procedures, such as the development of the positioning sensors, we lacked some working experience and we truly would have appreciated more support from the lecturers. In spite of that, our general opinion, in reference to the organizers, is very positive and we are very grateful for their support.

On the other hand, from Echo10P we are naturally conscious about things that could have gone better. First, the initial organization: the first weeks (even the first month and a half) we felt pretty disorientated as we didn't know very well how to approach the development of the project. That is, for example, we were pretty unsure about what the system really had to do, what necessities it had to satisfy and also what tasks each member of the group was going to carry out. It took us a while but, as soon as we all knew what to do, the project started to move forward.

Moreover, the documentation we handed in, specially at the beginning of the term, was pretty insufficient as it did not fulfill what engineering projects demand. That is, detailing exactly what our product was thought for, who was it though for and, the most important, the requirement specifications. Numbers, quantitative parameters. We learnt, for further projects, that clients will always require numeric parameters, either for voltage, image resolution, processing time, final price etc…

Finally, we'd like to briefly analyze the final product presentation, carried out the last day of the term at the school. After talking to the lecturers, we realized that, although our presentation was pretty fluent, we missed some detailed explanation about what exactly anesthetists do when they are dealing with chronic patients. Why do they want a product like ours? What is their daily job like? How do they prick the needle in order to inject the anesthesia? All these questions should have been answered more deeply and, as a group, we'd like to make clear that we'll solve this out for further presentations.