ALFA CENTAURI

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Every day we are exposed to UVB and UVA rays, and even if we want to escape from the intensity of the sun in open places such as shopping malls or parks through table umbrellas. This will not always be possible since with the passing of the hours the sun completes its trajectory, making even a static table umbrella dysfunctional in a few hours, this is harmful to the skin since it causes rapid aging and skin cancer. Therefore, the idea of solving this problem was implemented with the development of an umbrella robot that follows the path of the sun, providing shade in all directions with respect to the movement of the sun.

Keywords— parasol;sun;robot;rays;rviz;gazebo

I. INTRODUCTION

During the development of robotics, it has overcome great challenges that several years ago were believed impossible to overcome, but one of the things that robotics is most proud of is the fact of being able to change everyday things to be transformed into objects with multiple functionalities that open new fields in comfort, study, health among others.

With this purpose, it is sought to implement a robotic design, for a situation of daily life, a problem that occurs that not many people seek to solve or do not give importance to, and that is that these types of problems are the ones that generate the most consequences due to it. abandonment or disinterest of people for its solution, thus in this document the analysis, study and solution of a daily problem is sought by applying all the knowledge seen in the subject of Robotics, concluding with a robot that can satisfy the needs of the people and finalizing that the acquired knowledge was applied correctly.

For this, the analysis of different environments where a problem is presented is carried out, this is mostly inspired by the situations that occur on the campus of the Universidad Autónoma de Occidente, to later carry out a more careful study focused on a local market, thus generating a solution with application in robotics.

II. THEORETICAL FRAMEWORK

A. Sunlight

Sunlight consists of a spectrum phenomenon of rays of different wavelengths, thus visible light has a wavelength of 400 to 700 nm, thus ultraviolet or UV light has an even more minute length reaching 280 to 400nm and finally you have the invisible infrared light has a wavelength greater than 700nm at 1nm, so the longer wavelengths, visible and infrared light are able to penetrate deeper into the skin. In summary, in the broadest sense of the word, sunlight is the total spectrum of electromagnetic radiation from the sun, this occurs during the hours in which the sun points directly at the earth in the cycle known as the day.

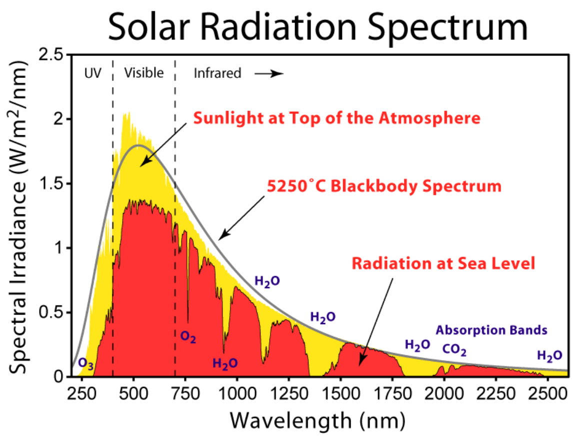

Image 1. Spectrum of solar radiation

This sunlight in turn generates thermal radiation, which is produced directly by the sun's radiation and is different from the increase in atmospheric temperature due to radioactive heating of the atmosphere by solar radiation.

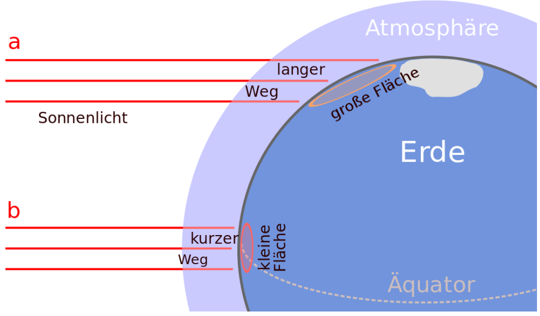

Image 2. Reflection of sunlight on the ground

Direct sunlight can provide around 93 lumens of illumination per watt of electromagnetic power, including infrared, visible and ultraviolet, which is a fundamental factor in the process of photosynthesis, so important for life.

B. Umbrella

Image 3. Traditional umbrellas

The umbrella is an object for manual use that varies in size, being the smallest size for one person or a large one that covers multiple people. An umbrella differs from an umbrella since it is usually larger, so its main use is to protect us from the sun as well as from the rain, being the most representative element in places with open spaces such as beaches or in places where there is a greater presence of the sun.

This object is said to be of Chinese origin, since it is recounted in paintings that date back about 4,000 years, both in written texts and in paintings, thus being the Eastern civilization as the greatest enhancer of the culture of the use of umbrellas, initially representing a social symbology, even though in the 9th century it was used exclusively in the upper classes.

Within the world of umbrellas, these are made of different resistant materials, the main material being plastic or canvas, while its structure consists of an infinite number of materials that depend on the place and the use that you want to give the object.

C. Gazebo

GAZEBO

Image 4. Gazebo logo

Gazebo is a simulator of multiple robots with an open programming orientation, being able to simulate a series of robots, sensors and objects generating a three-dimensional world, the strongest point of this simulator being the ability to generate movement and communication of the robots. data, thus being able to connect different sensors and instruments in real life to be able to see their behavior in the simulation environment.

D. Rviz

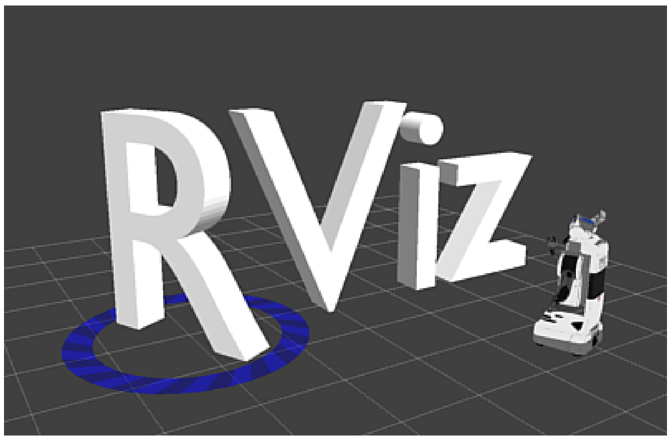

Image 5. RViz interface

Rviz is a graphical interface of ROS that allows the visualization of various types of information, from physical models to the generation of data in a physical way, in this work the most important complements will be:

- Robot Model: This plugin allows the display of the robot model according to its URDF model description provided to it.

- TF: This plugin allows the display of the position and orientation of all the frames that make up the TF hierarchy.

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The main objective of this document is the ability to identify and analyze engineering problems, generating a solution based on knowledge in the field of robotics.

Now the skills that you want the student to develop are:

- Ability to identify, formulate, and solve complex engineering problems by applying engineering, science, and math principles.

- Ability to acquire and apply new knowledge when required, using appropriate learning strategies.

III. DESCRIPTION OF THE PROBLEM

The Autonomous University of the West is characterized by having several green areas, these are accompanied by tables and umbrellas for the sun, but it has been analyzed that after the course of the day as the sun crosses the horizon, most of the umbrellas they become useless since they do not have the angle to be able to cover the table, sometimes leaving only one or even no chair in the shade, but what kind of impact can this have?.

MOTIVATION: We will all have to expose ourselves to the sun, in fact we expose ourselves daily whether to go to study, work, walk or simply to water the plants or take the dog out, we are constantly being bombarded by this sunlight and this does not mean it is bad In fact, we all need to expose ourselves to the sun to some extent, since thanks to this light we are able to manufacture vitamin D that helps the body absorb calcium.

But sunlight can also be dangerous, since excessive exposure to ultraviolet rays can cause damage to the skin, eyes, weaken the immune system and even cause skin cancer. In addition to this, in recent years there has been a trend in the increase in the entry of ultraviolet rays to planet earth, caused by different factors such as pollution, this causes that even young people 20 years old and below can develop skin cancer. Whiter-skinned people are the most susceptible to sunburn, as the skin pigment becomes darker, causing wrinkles and blemishes to appear, increasing the chances of skin cancer. For this reason, in public places such as shopping centers, parks, restaurants, cultural centers, etc. They have places that help protect people from the sun's rays, one of the most used methods are table umbrellas since they are relatively cheap and cover between 2 to 4 people, but as mentioned above, this solution is not 100%. effective, still generating high risks of sunstroke or burns, being under umbrellas that do not meet their main design objective.

What benefits are expected from this project?

It is desired to obtain an open space in the open air which is protected from UV rays covered with a shade which should not move during the day regardless of the position of the sun during it. In addition to providing a sense of security and tranquility in this same space for any user when using it.

What is the scope or constraint of the problem?

For reasons of time and resources, the expected result for this project is a functional scale prototype of the mechanism capable of meeting the given specifications, using the application of the knowledge acquired throughout the course as the basis for its operation, focusing on design processes and robotics. At the time of establishing the other limitations of the project, there was a certain idea based on a not very rigorous observation, which left the approach and development of the project in a very subjective concept; reason why tools such as the survey were used to different people considered as potential users of the product:

A survey was conducted on a total of 10 people, the information collected from these surveys is shown below:

1. **What bothers you most about a table umbrella?**

The heat that it is even in the shade, and that when there are strong winds but the day is sunny, is very annoying since the parasol begins to move everywhere even with the supports installed.

2. **Do you have any difficulties when assembling a table umbrella?**

If there are times, it is not clear from the plane that tubes are part of the base and which of the ends, in addition to some screws that do not match and it is necessary to apply pressure to make them square.

3. **Do the table umbrella seem dangerous to you?**

Yes! It seems dangerous to me mainly for children, since they start playing and sometimes they hit the umbrella and it falls right there hitting them, or on other occasions one wants to adjust the umbrella so that it gives more shade and the insurance comes loose and falls off.

4. **How often do you store the table umbrella?**

I keep it every time there is heavy rain or a lot of wind, but it is annoying since it is difficult to store and reassemble so I have not taken it out again even though we are in the dry season.

5. **If you had the opportunity to modify an aspect or characteristic of an umbrella, what would you do?**

I would like them to be cool and not hot despite being in the shade and I would also like it to be stored or unfolded by itself, that would save me an hour or two of my time. For the definition of the restrictions based on the idea that was previously had and with the information collected from the users, it is possible to land the project on a more established basis, where we say that the previously mentioned mechanism must:

- Follow the sun at all times.
- Be shock resistant.
- Works under exposure to ambient conditions.

PLANTEAMIENTO DE LA MISIÓN: Proyecto-Sombrilla Inteligente	
Descripción del producto	Sombrilla con capacidad de generar una sombra a todos los asientos independientemente de la posición del sol.
Propuesta de valor	-Fácil configuración. -Regulación de la altura. -Resistente a climas atípicos. -Batería de larga duración. -Fácil de guardar. -Posición inteligente.
Objetivos de mercado	-Precios competitivos que permitan generar volúmenes de venta -Ser líderes y generar un nuevo segmento en la venta de sombrillas inteligentes -Aceptación de clientes y usuarios a través de buenas reseñas
Mercado primario	-Entes que requieran el uso de sombrillas de mesa en el exterior (Centros comerciales, restaurantes, casas campestres, centros vacacionales etc) alrededor de la ciudad de Cali.
Premisas y restricciones	- Debe ser resistente a golpes - La lluvia no debe afectar el sistema - Debe verse bien en su entorno - Duración de carga de 1 semana - Debe permitir su uso conectado a un tomacorriente - Fácil mantenimiento - Debe seguir el sol en todo momento.
Agentes implicados	-Restaurante, centros recreativos y potenciales compradores. -Proveedores de piezas. -Cadena de producción. -Marketing y ventas. -Productos con funciones similares.

Image 6. Mission approach

- Be aesthetic in the environment.
- Have a long-lasting battery.
- Have a communication with the user.

Agents involved in the development of the project: Now the agents involved are those who are going to be affected by the product (in this case we take all those who have a benefit from this product). Taking this into account, the best method to be able to catalog and know the agents involved is through the Customer Value Chain Analysis or CVCA, which gave the following map:

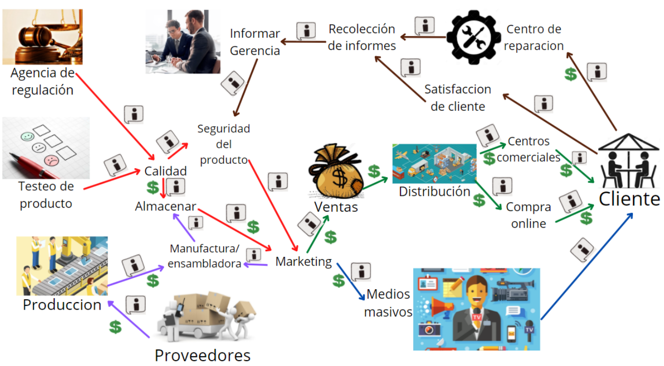


Image 7. Agents involved

From this CVCA we then observe that the agents involved are going to do:

- Production - Mass Media
- Suppliers - Marketing
- Client - Management

On the map we have more agents involved, but these are considered the most important since they are part of a simple line of production and sale. the line that can ensure a short but effective route to reach the customer. Now, within these agents involved we can define that the Client itself can become the most important, but this becomes relative when seeing that each one depends on each agent, it is true that one will be more relevant than another but to cover each One, it is necessary first to understand the customer, then to understand production, suppliers and finally marketing, so we have a simple line that seeks to make the product effective for the user, while also being easy to produce to generate large quantities.

Potential impacts of the developed product:
Now that its respective investigation has been carried out, of all the aspects that entail the physical creation of this solution, we can summarize it in a mission that will be divided into several sections as shown below:

How can we ensure the success of this product?

The success of this product is also ensured by observing different commercial solutions already existing in the market, thus we see the boom that this product is generating in said market. Analyzing these products we find that the most representative are:

ShadeCraft Robotics: It is a technology and robotics company based in Pasadena, California, the main mission of this company is to improve the quality of human life outdoors, this through industrial design, innovative technology and robotics. .

It debuted its first product known as Sunflower at CES 2017, which forever changed the outdoor landscape through the introduction of automation and technology in existing outdoor umbrellas, being the pioneer in generating IOT technology in a significant way to the outdoor landscape. Being supported

Image 8. ShadeCraft umbrella

by far, winning awards for innovation and promotion of renewable technologies.

FelsoGlass: It is a company dedicated exclusively to technical and commercial advice, sale and installation of enclosures with glass curtains, sliding doors, fixed

load-bearing structures, ***Image 9. FelsoGlass umbrella*** mobile roofs, pergolas. So the goal the main thing we seek is the balance between the aesthetic and the functional, offering products aimed at creating safe spaces that provide well-being and comfort and that also contribute to energy efficiency, its most characteristic product being the installation of mobile roofs, which when detecting the rain they close automatically, in the same way when detecting a certain amount of light this will open automatically giving way to greater ventilation, this also depends on the user and their preferences. This company is a leader in Europe in smart ceilings and home automation.

As can be seen, there are several products that generated a great impact, which feature the use of a certain level of intelligence to detect sunlight, or the automation of a common object such as umbrellas or roofs, for this reason We affirm that the product to be developed in this work can generate this impact since it will enter a market that is considered new, in which each object can bring a degree of innovation, impacting the sector to which it is directed.

IV. CONCEPT DESIGN AND SOLUTION

After carrying out several investigations through the quality house and the search for needs and requirements, the concept generation phase is reached, to carry out the concept, a transparent box must be created which will allow us to observe the operation of general way of the project, generating the following transparent box:

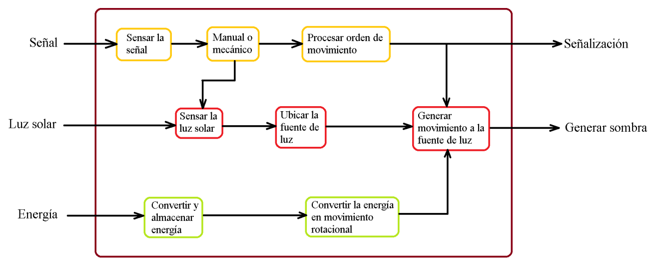


Imagen 10. Caja transparente de funciones

Now, as can be seen, we have several sub-function tables, where each function is vital for the generation of the final objective, which in this case is the Shadow Generation and the signaling of an order. Now the most important line in this case will be the one that receives sunlight as input, this is taken as the main one since from this the shadow will be generated, which is the final point, so to make this line also it is necessary to develop the other 2 lines, so based on this line we generate a brainstorm:

Taking as a line of focus the acquisition and manipulation of sunlight, a solution was given to the sub-problems that arose and based on this it was possible to generate a combination table of concepts with 13 different possible solutions. It was taken into account that some solutions to the subproblems have no way of relating to the solutions of the other subproblems, for example the case of the GPS solution proposal that can only be associated with the Geolocation and time solution proposal.

Concept 1:

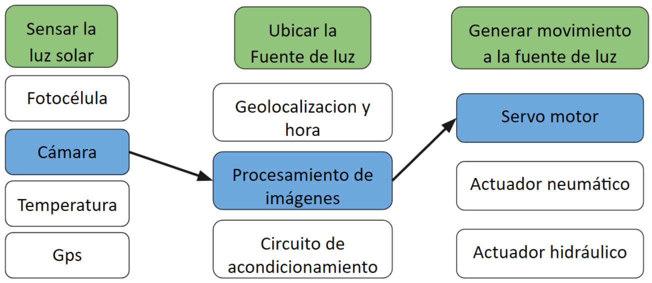


Image 11. Ideation concept 1

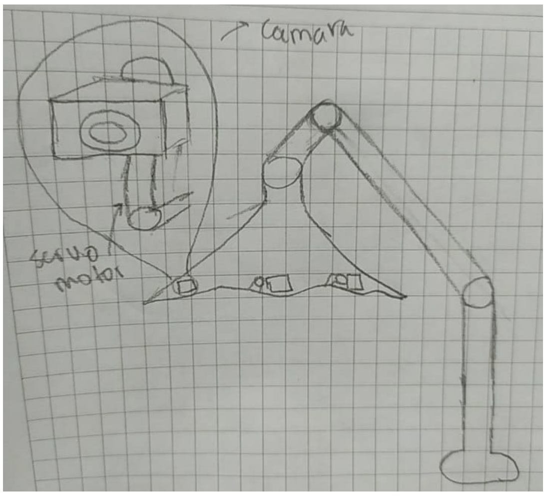


Image 12. Sketch of ideation concept 1

This concept consists of implementing cameras for image processing, this in order to establish the position of the sun, to later send the order to a servomotor, generating movement in the umbrella to the detected position.

Concept 2:

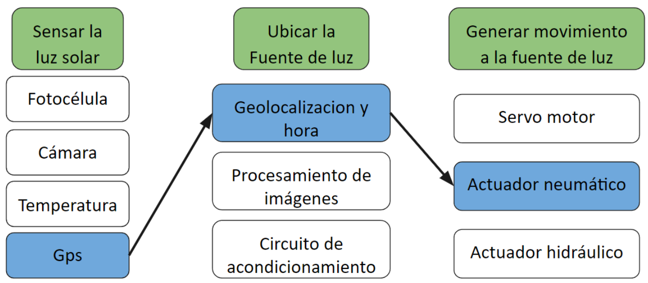


Image 13. Ideation concept 2

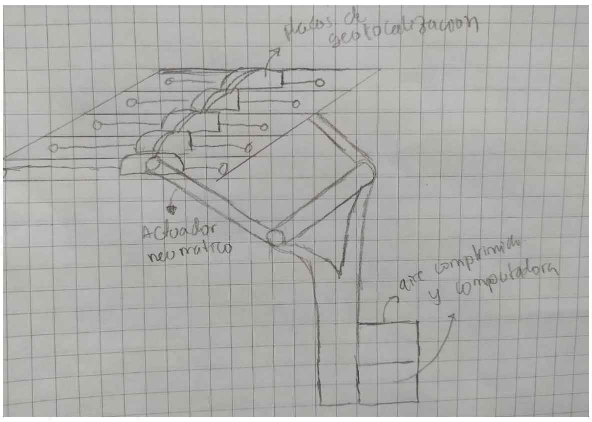


Imagen 14. Boceto del concepto 2 de ideación

This concept consists of making use of a time zone GPS for the location of the sun, with this later making use of pneumatic actuators for the creation of movement.

Concept 3:

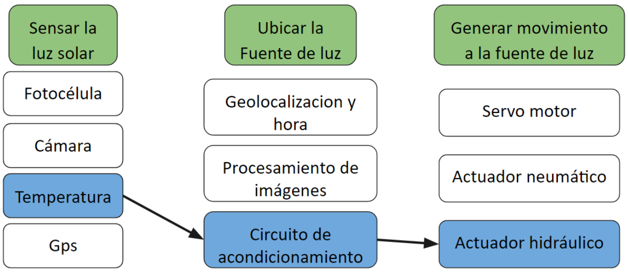


Image 15. Ideation concept 3

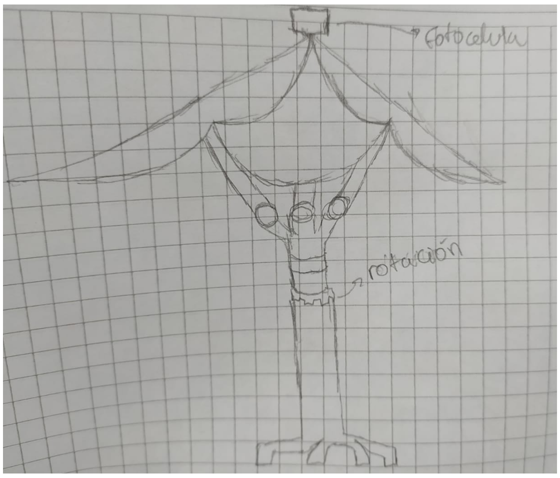


Image 16. Sketch of ideation concept 3

This third concept consists of making an approximation of the largest light source through a temperature sensor, with this subsequently generating a signal to a conditioning circuit, leading to a hydraulic actuator, either a series of pistons for the generation of movement. .

Solution selection: The selection of the concept was carried out through a two-level screening process, thus the result of this selection was decided that the best concept to develop is an amalgamation of concepts, thus the final development is the form of the concept 3 but combined with the operation of concept 2 for the information capture and processing part and finally a servomotor will be used for concept 3, obtaining the following:

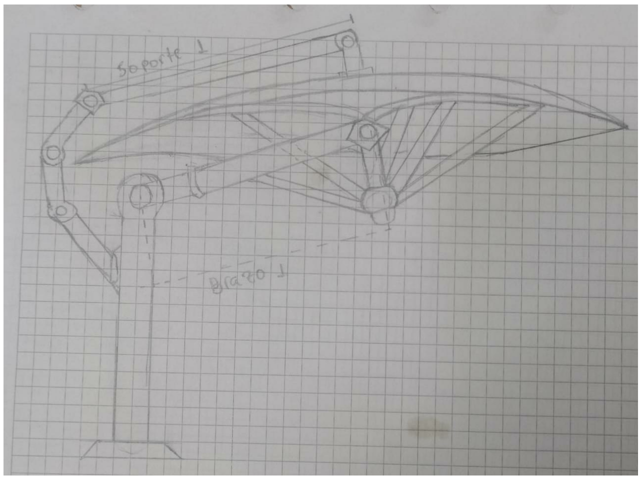
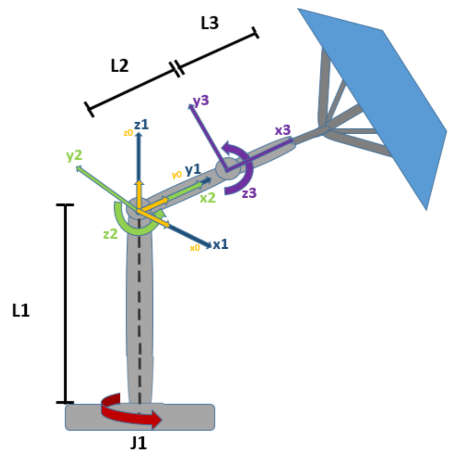


Image 17. Sketch of the final ideation concept

Thus we have the conceptual design to develop, it is that of an umbrella with tracking of sunlight through the time zone of the region in which the umbrella is located, then through a conditioning and geolocation circuit generate the signal for a system of servomotors to generate the movement and direction of the umbrella.

Development of the concept: Now that the concept to be worked on has been defined, it is necessary to be more precise in its dimensions and mainly in the number of joints, which is why the following design was made:



In this, the degrees of freedom that the robot will have are observed, this is necessary to be able to generate two important matrices for our project, which is the kinematics

Image 18. Analysis of the joints of the direct and inverse system of the robot. With these two definitions we can control the robot in the future but first it is necessary to calculate these matrices:

The first thing then is the calculation of the direct kinematics (all these calculations are referenced with Image 18).

i	αi-1	ai-1	di	Θi
1	0	0	0	Θ_1
2	90°	0	0	Θ_2
3	0	L_2	0	Θ_3

Table 1. Direct kinematics

So the forward kinematics given in their independent matrices are:

$$ {}^{0}_{1}T = \begin{bmatrix} c1 & -s1 & 0 & 0 \\ s1 & c1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{1}_{2}T = \begin{bmatrix} c2 & -s2 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ s2 & c2 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{3}_{2}T = \begin{bmatrix} c3 & -s3 & 0 & L_2 \\ s3 & c3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

In order to have a specific position with respect to the variables shown in table 1, it is necessary to carry out the inverse kinematics, so it is necessary to carry out the inverse with transformation matrices:

$$ {}^{0}_{3}T = {}^{0}_{1}T\,{}^{1}_{2}T\,{}^{2}_{3}T $$

$$ ({}^{0}_{1}T)^{-1}T = {}^{1}_{2}T\,{}^{2}_{3}T $$

$$ \begin{bmatrix} c1 & s1 & 0 & 0 \\ -s1 & c1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} n_x & O_x & a_x & P_x \\ n_y & O_y & a_y & P_y \\ n_z & O_z & a_z & P_z \\ 0 & 0 & 0 & 1 \end{bmatrix} = {}^{1}_{2}T\,{}^{2}_{3}T $$

Choosing the element (3,4)

$$ -P_x s1 + P_y c1 = 0 $$

$$ \theta_1 = arctan2\left(\frac{P_y}{P_x}\right) $$

$$ ({}^{1}_{2}T)^{-1}({}^{0}_{1}T)^{-1}T = {}^{2}_{3}T $$

$$ \begin{bmatrix} c2 & 0 & s2 & 0 \\ -s2 & 0 & c2 & 0 \\ 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c1 & s1 & 0 & 0 \\ -s1 & c1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} n_x & O_x & a_x & P_x \\ n_y & O_y & a_y & P_y \\ n_z & O_z & a_z & P_z \\ 0 & 0 & 0 & 1 \end{bmatrix} = {}^{2}_{3}T $$

Choosing the element (2,4)

$$ -P_x c1s2 - P_y s1s2 + P_z c2 = 0 $$

$$ s2(-P_x c1 - P_y s1) + P_z c2 = 0 $$

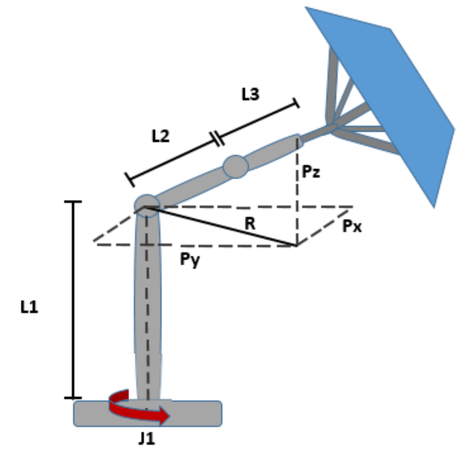
$$ \theta_2 = arctan2 - \frac{(-P_x c1 - P_y s1)}{P_z} $$

Choosing the element (1,4)

$$ P_x c1c2 + P_y c2s1 + P_z s2 = L_2 $$

$$ c2(P_x c1 + P_y s1) + P_z s2 = L_2 $$

For θ3 the geometric method was applied



$$ R^2 = {P_y}^2 + {P_x}^2 $$

$$ R^2 + {P_z}^2 = L_2^2 + L_3^2 + 2 * L_2^2 * L_3^2 cosq_3 $$

Solve cosq3 and replace R

$$ cosq_3 = \frac{{P_x}^2 + {P_y}^2 + {P_z}^2 - L_2^2 - L_3^2}{2 * L_2^2 * L_3^2} $$

Put the equation with sine term

$$ sinq_3 = \pm\sqrt{1 - cos^2 q_3} $$

So when obtaining in terms of sine and cosine we would have:

$$ \theta_3 = arctan2\frac{\pm\sqrt{1 - cos^2 q_3}}{cosq_3} $$

Finding the inverse in different ways means that a method does not simply find all the respective angles, because each robot has a structure that makes a method applicable, but it does not result in giving all the angles necessary for the result of the inverse kinematics.

After defining the concept that we are going to use (mainly its shape and design) we proceed to make a 3d model, this through the SolidWorks simulator.

Now several improvements have been made with respect to the drawing, the first thing is the lower part of the umbrella, as well as it can be observe the base is wider in addition to having two bases, one will be the rotational one and the second will serve as a means of gripping the entire umbrella. In addition, the additional arm that was in the drawing was eliminated since it is considered to be unnecessary, a single arm gives enough strength and stability to the umbrella. Another point to note is that in the modeling The entire parasol was not made (with fabric) since what interests us in these models are the joints it will have, so we can define the degrees of freedom.

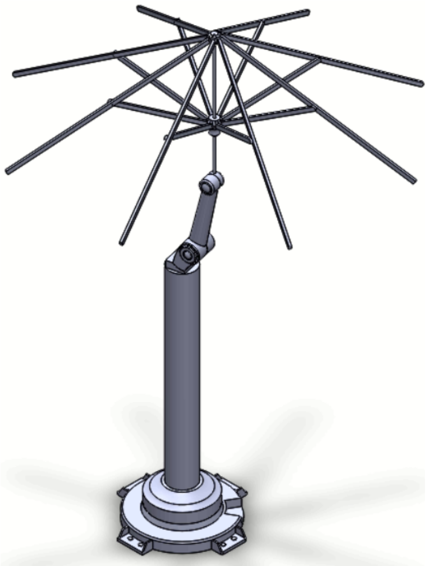


Image 19. 3D design of the robot

After doing the modeling, we can do an exploded view to see the different joints created in more detail.

With the explosive view, we find 3 different degrees of freedom, one is the one that connects the rotational base with the fixed base, the second is the one that connects the arm with the trunk, and the third is the union between the structure of the umbrella and the arm. Thus, having the degrees of freedom that our project manages, it will be a total of 3.

Image 20. Exploded design in SolidWorks of the initial model.

If the reader of this project wishes to see how the explosion view is generated, the simulation of said view is shown in the following link:https://drive.google.com/file/d/1Hm76yiQlzUkRinFxrnF0uvHikxgFJceC/view?resourcekey

V. Visualization of the solution using RVIZ

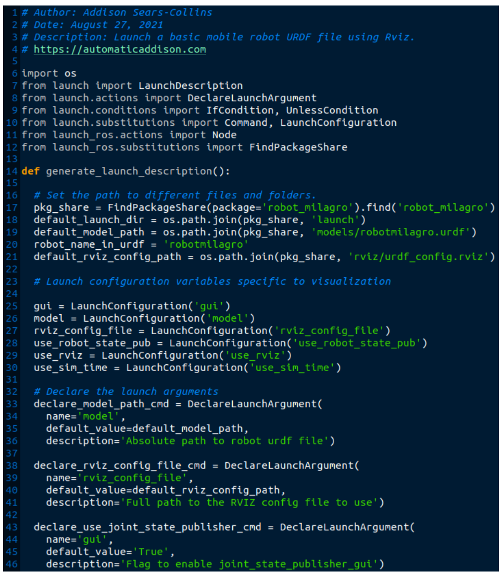
After having our model in solidwork through a tool that this simulator has, we generate the urdf of said model:

```xml
<?xml version="1.0" encoding="utf-8"?>
<robot
  name="robotmilagro">
  <link
    name="base2_Link">
    <inertial>
      <origin
        xyz="0.00530265169310419 0.00528029914101924 0.0513462352345183"
        rpy="0 0 0" />
      <mass
        value="37.3619805208222" />
      <inertia
        ixx="1.07878719190163"
        ixy="0.0421503007964398"
        ixz="0.00134509247170474"
        iyy="1.07844693370143"
        iyz="0.00131074568973874"
        izz="2.0532044687573" />
    </inertial>
    <visual>
      <origin
        xyz="0 0 0"
        rpy="0 0 0" />
      <geometry>
        <mesh
          filename="package://robot_milagro/meshes/base_Link.STL" />
      </geometry>
      <material
        name="">
        <color
          rgba="0.458 0.6 0.92564 1" />
      </material>
    </visual>
    <collision>
      <origin
        xyz="0 0 0"
        rpy="0 0 0" />
      <geometry>
        <mesh
          filename="package://robot_milagro/meshes/base_Link.STL" />
      </geometry>
    </collision>
  </link>
```

If you want to see the complete code enter our Git:

https://github.com/victorAlvarezValencia/ProyectoSombrillaInteligente/blob/main/robot_milagro/urdf/robotmilagro.urdf

Thus we have the description of our robot, this accompanied by the meshes that contain the material of the robot, we can generate a 3d visualization of it, but for that it is necessary to generate a file to be able to make a reconstruction of the URDF, that is why it is necessary to create from a Launch file:



```python
# Author: Addison Sears-Collins
# Date: August 27, 2021
# Description: Launch a basic mobile robot URDF file using Rviz.
# https://automaticaddison.com

import os
from launch import LaunchDescription
from launch.actions import DeclareLaunchArgument
from launch.conditions import IfCondition, UnlessCondition
from launch.substitutions import Command, LaunchConfiguration
from launch_ros.actions import Node
from launch_ros.substitutions import FindPackageShare

def generate_launch_description():

  # Set the path to different files and folders.
  pkg_share = FindPackageShare(package='robot_milagro').find('robot_milagro')
  default_launch_dir = os.path.join(pkg_share, 'launch')
  default_model_path = os.path.join(pkg_share, 'models/robotmilagro.urdf')
  robot_name_in_urdf = 'robotmilagro'
  default_rviz_config_path = os.path.join(pkg_share, 'rviz/urdf_config.rviz')

  # Launch configuration variables specific to visualization

  gui = LaunchConfiguration('gui')
  model = LaunchConfiguration('model')
  rviz_config_file = LaunchConfiguration('rviz_config_file')
  use_robot_state_pub = LaunchConfiguration('use_robot_state_pub')
  use_rviz = LaunchConfiguration('use_rviz')
  use_sim_time = LaunchConfiguration('use_sim_time')

  # Declare the launch arguments
  declare_model_path_cmd = DeclareLaunchArgument(
    name='model',
    default_value=default_model_path,
    description='Absolute path to robot urdf file')

  declare_rviz_config_file_cmd = DeclareLaunchArgument(
    name='rviz_config_file',
    default_value=default_rviz_config_path,
    description='Full path to the RVIZ config file to use')

  declare_use_joint_state_publisher_cmd = DeclareLaunchArgument(
    name='gui',
    default_value='True',
    description='Flag to enable joint_state_publisher_gui')
```

If you want to see the complete code enter our Git:

https://github.com/victorAlvarezValencia/ProyectoSombrillaInteligente/blob/main/robot_milagro/launch/robotprueba_display.launch.py

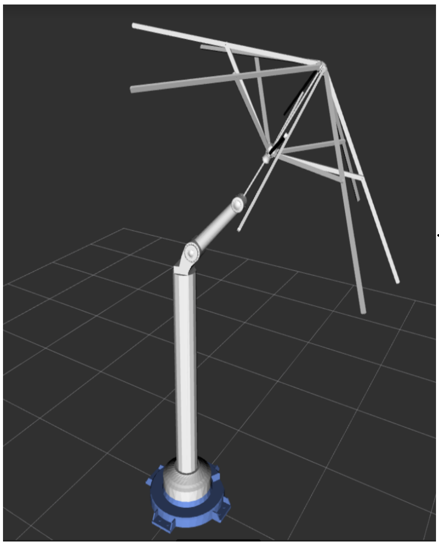


Image 21. Umbrella model simulated in RViz

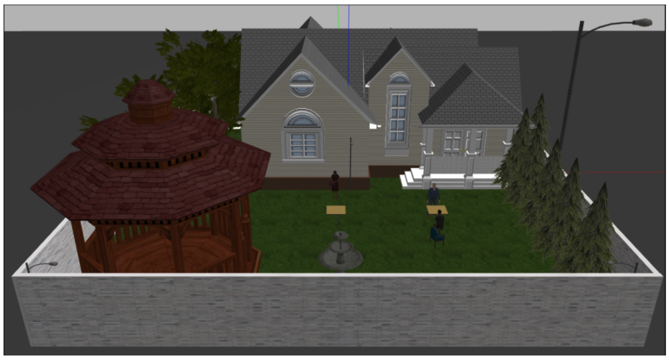
In this launch file, the Joint state publishes is invoked, which is in charge of calling all the joints of the robot, then there is the robot description, which is the description of the robot and then the transformation publisher that will generate the transformations with TFT help to convert entities and geometries from the URDF to a physical visualization, with this we generate the following model:

As can be seen, the conversion of the SolidWorks 3d model was successful. This is thanks to the fact that their respective axes and articulation were generated correctly in the Urdf export extension in SolidWorks.

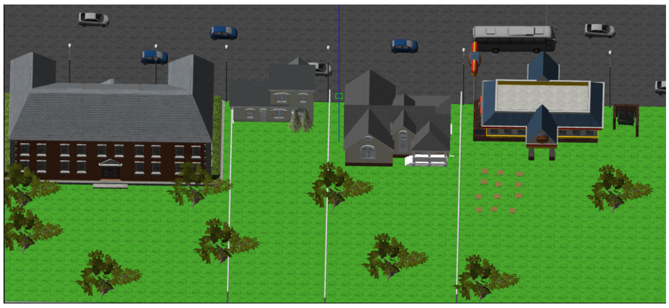
An additional fact that can be observed is the fact that the colors change, this change was made in the urdf, in addition to this the limits of movement of the Joints were also made, thus we prevent them from going through the entire solid body of the umbrella, generating a more realistic environment. If you want to see the movement of the joints which consists of Joint_Link1 which corresponds to a rotational movement of 360 degrees or a continuous joint, Joint_Link2, which will be the movement of the robotic arm, which corresponds to that of a rotational joint and finally the Joint_Link3 which corresponds to a rotational joint and this is located at the junction between the structure of the umbrella and the robotic arm, all this can be seen in motion in Rviz in the following video:https://drive.google.com/file/d/16QPIN1F-y4Hyw9tn7hkRJccvrU11JNj2/view?resourcekey

VI. Visualization in the Gazebo simulator

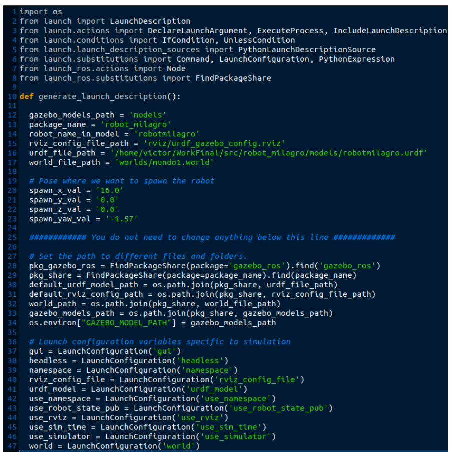
Our robot has already been visualized in rviz, this means that the code and programming are correct, in addition the direct and inverse kinematics were calculated, these components are required in the Gazebo simulator since the real simulation of the robot's operation begins here, but before it is necessary to generate a simulated environment in which we can observe a world that is close to the environment in which the umbrella would work, for this the following world was designed:



As can be seen in the previous figure, the simulated environment will be a house with a garden, in addition to this it is a house from stratum 4 and above, this is because the natural buyers are simulated here, who will mostly be people of these kinds , now for potential buyers who would be shopping malls or restaurants, the generated world is as follows:



As this world is observed, it is much more loaded, so for a greater fluidity in the simulation, the first world will be used. Continuing with the simulation, it is necessary to generate our umbrella in this created environment, for this a Launch is programmed that allows us to connect to a Gazebo server to subsequently generate the robot spawn, this obviously implies using the same rviz configuration to generate all the joints and dynamics of the robot:



```python
import os
from launch import LaunchDescription
from launch.actions import DeclareLaunchArgument, ExecuteProcess, IncludeLaunchDescription
from launch.conditions import IfCondition, UnlessCondition
from launch.launch_description_sources import PythonLaunchDescriptionSource
from launch.substitutions import Command, LaunchConfiguration, PythonExpression
from launch_ros.actions import Node
from launch_ros.substitutions import FindPackageShare

def generate_launch_description():

  gazebo_models_path = 'models'
  package_name = 'robot_milagro'
  robot_name_in_model = 'robotmilagro'
  rviz_config_file_path = 'rviz/urdf_gazebo_config.rviz'
  urdf_file_path = '/home/victor/WorkFinal/src/robot_milagro/models/robotmilagro.urdf'
  world_file_path = 'worlds/mundo1.world'

  # Pose where we want to spawn the robot
  spawn_x_val = '16.0'
  spawn_y_val = '0.0'
  spawn_z_val = '0.0'
  spawn_yaw_val = '-1.57'

  ############ You do not need to change anything below this line #############

  # Set the path to different files and folders.
  pkg_gazebo_ros = FindPackageShare(package='gazebo_ros').find('gazebo_ros')
  pkg_share = FindPackageShare(package=package_name).find(package_name)
  default_urdf_model_path = os.path.join(pkg_share, urdf_file_path)
  default_rviz_config_path = os.path.join(pkg_share, rviz_config_file_path)
  world_path = os.path.join(pkg_share, world_file_path)
  gazebo_models_path = os.path.join(pkg_share, gazebo_models_path)
  os.environ["GAZEBO_MODEL_PATH"] = gazebo_models_path

  # Launch configuration variables specific to simulation
  gui = LaunchConfiguration('gui')
  headless = LaunchConfiguration('headless')
  namespace = LaunchConfiguration('namespace')
  rviz_config_file = LaunchConfiguration('rviz_config_file')
  urdf_model = LaunchConfiguration('urdf_model')
  use_namespace = LaunchConfiguration('use_namespace')
  use_robot_state_pub = LaunchConfiguration('use_robot_state_pub')
  use_rviz = LaunchConfiguration('use_rviz')
  use_sim_time = LaunchConfiguration('use_sim_time')
  use_simulator = LaunchConfiguration('use_simulator')
  world = LaunchConfiguration('world')
```

If you want to see the complete code enter our Git:

https://github.com/victorAlvarezValencia/ProyectoSombrillaInteligente/blob/main/robot_milagro/launch/3_gazebo_controller.launch.py

After designing the launch we can now bring our robot to the Gazebo simulator: As can be seen, the dimensions of the robot seem somewhat exaggerated compared to people, but this is because the additional distance allows a greater shadow to be projected, in addition to the fact that due to the safety factor it is mandatory to create a certain height between the umbrella that is the moving part. This can prevent people from being hit when the umbrella generates its trajectories.

How so paths? And if at this point we have investigated and formulated an engineering problem, a solution has also been developed, but we still cannot say that this solution is complete, since at this point in the simulation the umbrella is only moving through inertia of your Joints, this is an item that Gazebo adds. But it is not the answer that you want to look for since, remembering the stated objective, it is necessary for the solution to be able to track sunlight.

Unfortunately, in the robotics course we do not have enough knowledge to make use of real sensors to be connected to Ros and later to Gazebo to generate said interaction instead, what we can do is a series of already defined trajectories, in order to verify the functionality of the umbrella, for this it is necessary to create a subscriber node in the gazebo, so that when a publisher node is activated, it immediately registers to receive the path command, with this in mind it is necessary to make the following changes in the Gazebo Launch:

```python
# Launch the robot
spawn_entity_cmd = Node(
  package='gazebo_ros',
  executable='spawn_entity.py',
  arguments=['-entity', robot_name_in_model,
             '-topic', 'robot_description',
                 '-x', spawn_x_val,
                 '-y', spawn_y_val,
                 '-z', spawn_z_val,
                 '-Y', spawn_yaw_val],
                 output='screen')
declare_use_joint_state_broadcaster_cmd = ExecuteProcess(
          cmd=['ros2', 'control', 'load_controller', '--set-state', 'start','joint_state_broadcaster'],
          output='screen')

declare_use_joint_state_trajectory_controller_cmd = ExecuteProcess(
          cmd=['ros2', 'control', 'load_controller', '--set-state', 'start', 'joint_trajectory_controller'],
          output='screen')

ld = LaunchDescription()
     # Declare the launch options
ld.add_action(declare_use_joint_state_publisher_cmd)
ld.add_action(declare_namespace_cmd)
ld.add_action(declare_use_namespace_cmd)
ld.add_action(declare_rviz_config_file_cmd)
ld.add_action(declare_simulator_cmd)
ld.add_action(declare_urdf_model_path_cmd)
ld.add_action(declare_use_robot_state_pub_cmd)
ld.add_action(declare_use_rviz_cmd)
ld.add_action(declare_use_sim_time_cmd)
ld.add_action(declare_use_simulator_cmd)
ld.add_action(declare_world_cmd)
ld.add_action(declare_use_joint_state_broadcaster_cmd)
ld.add_action(declare_use_joint_state_trajectory_controller_cmd)
```

*If you want to see the complete code enter our Git:*https://github.com/victorAlvarezValencia/ProyectoSombrillaInteligente/blob/main/robot_milagro/launch/3_gazebo_controller.launch.py

Construction of a prototype

After doing their respective investigations, and reaching this point in which it was possible to generate several routes that simulate the operation of the umbrella, we have the certainty and confidence that a physical model of this arm can be built. , now said physical model aims to demonstrate that the design and shape of the robot are the correct path for the construction of a final prototype, for this a series of procedures were carried out for its construction:
As mentioned above, the objective of this prototype was to verify that the chosen design and functionality concept are correct or otherwise require modification, remembering that even the sales version, every project can be constantly changing. and improvements, with this in mind we start with the detailed design:

Improvements in solidworks: Starting with a new solid design, this design will try to be implemented in the physical prototype, now as you can see the new design focuses on aesthetics and functionality, thus having the umbrella is divided into two parts, allowing only one to be rotational, this provides greater ease by moving a smaller amount of weight, in addition the shape of the arm is eliminated leaving only one tube that will serve as a robotic arm:

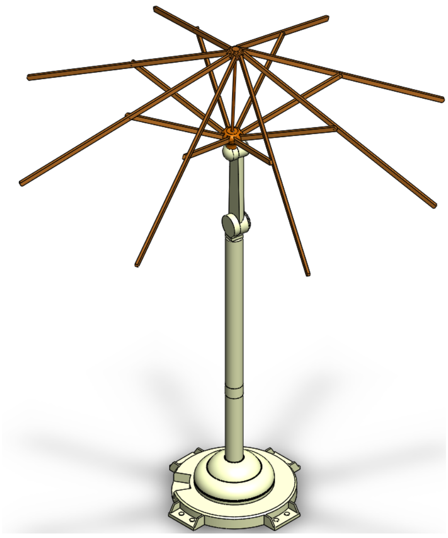


Image 22. Umbrella 3D design

With this new design, we find several benefits apart from greater ease of movement, it also allows future improvements to be implemented as well as the exchange of parts is much easier through a modular configuration, with this we obtain the new views of the umbrella:

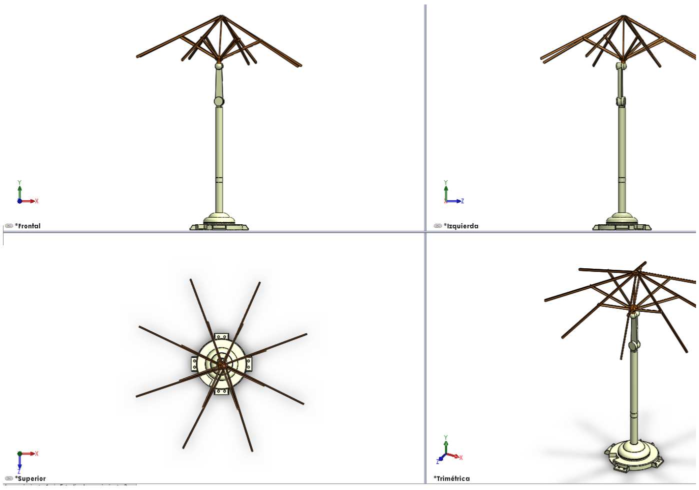
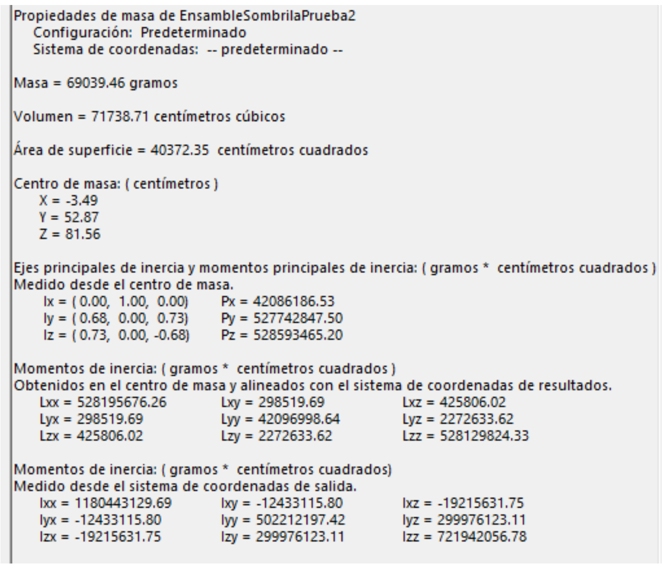


Image 23. Views of the 3D design of the umbrella

Now, as we have a more complex solidWork design, it is time to transfer this information to a real format, for this we first observe the weight of the umbrella and the moments of inertia (The weight is based on an aluminum alloy, in addition to the points of inertia are needed for the urdf model in case of new simulations).



Propiedades de masa de EnsambleSombrilaPrueba2
Configuración: Predeterminado
Sistema de coordenadas: -- predeterminado --

Masa = 69039.46 gramos

Volumen = 71738.71 centímetros cúbicos

Área de superficie = 40372.35 centímetros cuadrados

Centro de masa: (centímetros)
X = -3.49
Y = 52.87
Z = 81.56

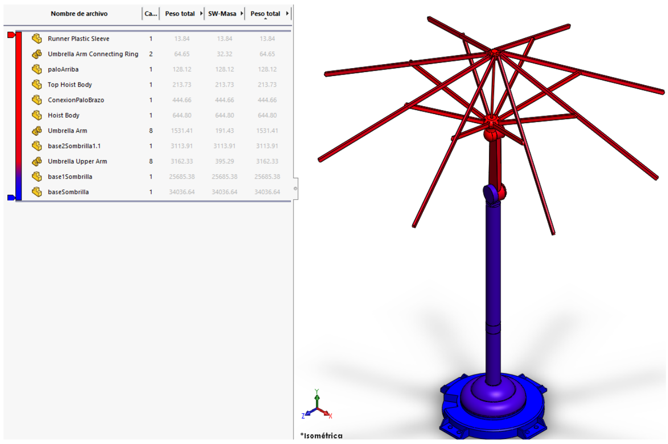
Ejes principales de inercia y momentos principales de inercia: (gramos * centímetros cuadrados)
Medido desde el centro de masa.
Ix = (0.00, 1.00, 0.00) Px = 42086186.53
Iy = (0.68, 0.00, 0.73) Py = 527742847.50
Iz = (0.73, 0.00, -0.68) Pz = 528593465.20

Momentos de inercia: (gramos * centímetros cuadrados)
Obtenidos en el centro de masa y alineados con el sistema de coordenadas de resultados.
Lxx = 528195676.26 Lxy = 298519.69 Lxz = 425806.02
Lyx = 298519.69 Lyy = 42096998.64 Lyz = 2272633.62
Lzx = 425806.02 Lzy = 2272633.62 Lzz = 528129824.33

Momentos de inercia: (gramos * centímetros cuadrados)
Medido desde el sistema de coordenadas de salida.
Ixx = 1180443129.69 Ixy = -12433115.80 Ixz = -19215631.75
Iyx = -12433115.80 Iyy = 502212197.42 Iyz = 299976123.11
Izx = -19215631.75 Izy = 299976123.11 Izz = 721942056.78

Image 24. Properties of the sunshade material

As we can see from the following table, the weight of the umbrella is somewhat high, in addition to its volume, but considering the dimensions of the product, it is understood that it is normal, even so to ensure that the mass is distributed in such a way that the lightest part is the part of the arm and the umbrella, we carry out a mass distribution study in the SolidWorks simulator:



Nombre de archivo	Ca...	Peso total	SW-Masa	Peso total
Runner Plastic Sleeve	1	13.84	13.84	13.84
Umbrella Arm Connecting Ring	2	64.65	32.32	64.65
paloArriba	1	128.12	128.12	128.12
Top Hoist Body	1	213.73	213.73	213.73
ConexionPaloBrazo	1	444.66	444.66	444.66
Hoist Body	1	644.80	644.80	644.80
Umbrella Arm	8	1531.41	191.43	1531.41
base2Sombrilla1.1	1	3113.91	3113.91	3113.91
Umbrella Upper Arm	8	3162.33	395.29	3162.33
base1Sombrilla	1	25685.38	25685.38	25685.38
baseSombrilla	1	34036.64	34036.64	34036.64

Image 25. Mass analysis in SolidWorks

As can be seen, the simulator highlights that the greatest weight and mass are distributed both in the base and in the main trunk of the umbrella, and otherwise the umbrella is the lightest part, in addition to this, remembering that the trunk is sectioned. in two parts, then allows the mass to be moved to be less than that shown in the solid, thus observing that its efficiency is greater. Now that we've made sure that the layout is correct, that the tolerances don't result in bad joint movement, and that the new design allows for more freedom of movement, it's time for drawing generation:

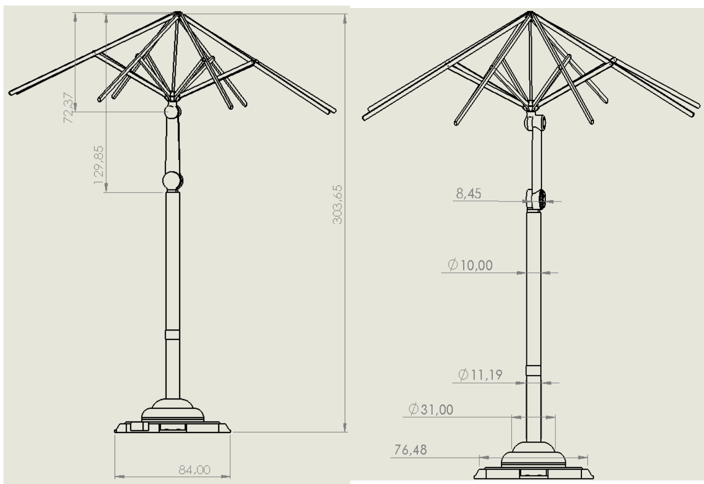


Image 26. Plan with measurements of the model in SolidWorks

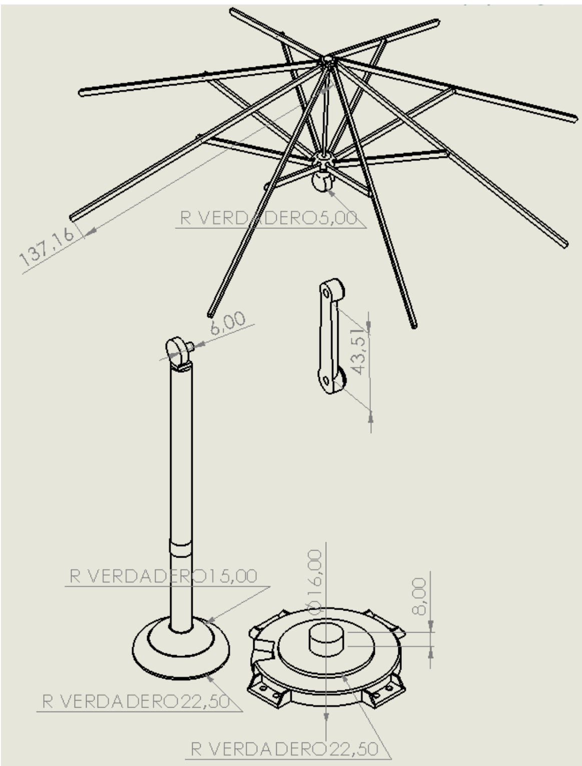


Image 27. Plan with measurements of the model in SolidWorks

Here we have all the necessary measures for the design, which when compared to those of a normal umbrella, it is concluded that they are perfectly similar, this is necessary since it must be ensured that the umbrella enters the market with similarities of competitors, in order to empathize with new customers.

Physical Assembly: After obtaining the plans and dimensions of the umbrella, it is necessary to start making a more specific prototype, for this three major problems were found:

-Dimensions: Due to the dimensions of the umbrella, its handling is complex and expensive with the budget that is available, therefore to solve this it was reduced and a prototype of approximately 1:2 scale was made, since if it is done by the Otherwise very small, the functionality would not be demonstrated.

-Mechanisms: Mechanisms such as motors turned out to be more difficult to obtain due to their costs, for this an alternative was made that will be seen later.

-Material: Due to the dimensions and shape of the umbrella, materials such as wood or Styrofoam are not capable of supporting the weight and allowing movement, therefore, for the architecture of the prototype, an unusual material is used for prototyping.

After solving these problems that arose at the time of beginning the physical implementation, it begins with the base and structure of the umbrella, for which PVC tubes or pipes are used, since they are resistant, they also have defined dimensions. that they sell multiple accessories such as elbows, or ball bearings that have the same dimensions, so it begins with their construction:

Image 28. Prototype construction process

This is the base of the umbrella, to be as ecological as possible with the environment, bed boards were reused for the construction of the base, later the rest of the robot was built:

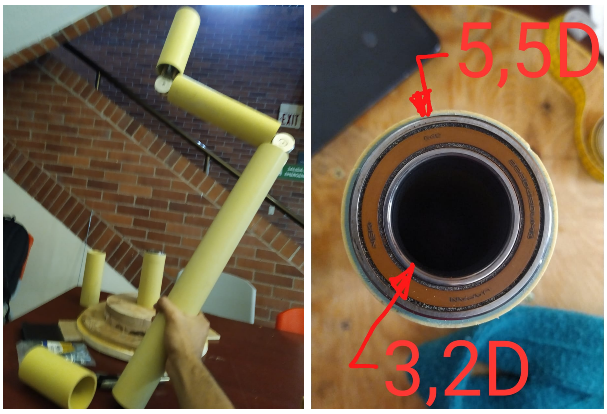


Image 29. Construction of the external structure of the system

Here the first functionalities begin to be developed, which in this case will be the rotational movement of the trunk, for this two tubes are used, the smallest one contains a bearing, which allows it to rotate on its own axis, later a tube is inserted , of the size of the internal diameter of the bearing:

Image 30. Internal and external measurements of the main tube

Then with a circle of wood in the second PVC tube, we join both sections, thus having the structure of the umbrella:

As can be seen, the height of the umbrella is in the middle ground, not being so small that it is useless, nor being the full dimensions of a real umbrella, which allows us greater mobility and ease when it comes to experiment with the motors, even so this structure is not solid enough to support

Image 31. View of the first prototype presented

itself, so the next steps is to integrate orthogonal supports, with brakes, to generate some resistance, in addition to limiting the movement through the use of wooden shafts :

Image 32. View of the physical model in the final joint prototyping laboratory

With this we have the complete and functional umbrella architecture, now the next step is:

Functionality: In the concept it was defined that **SERVOMOTORS OR GEARMOTORS** would be used, unfortunately we faced the reality that the weight of the umbrella is too great to be lifted by the motors, initially discarding the idea. So we returned to the generation of concepts, and we analyzed that the second concept that came close to winning was the implementation of hydraulics for the movement of the umbrella, and although it was discarded due to its difficult handling and low precision compared to servomotors , it was decided to generate a new alternative, which consists of combining the hydraulics with the motors, so the first tests were carried out:

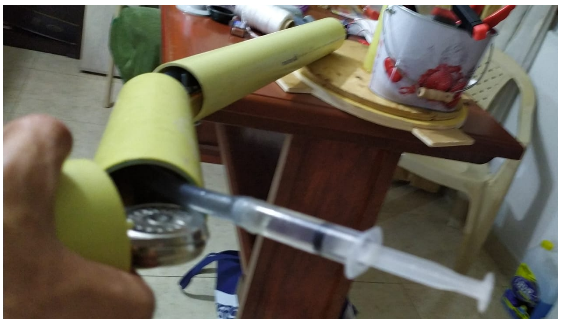


Image 33. Syringe used for orientation manipulation

With the use of small syringes at both ends, it was determined that it is possible to move the arm with these, but the size of the syringes and the pressure were not yet sufficient, in addition to the fact that there was a great limitation and that was the length of the syringes. syringes, for that the concept of PUMP MOTORS is introduced, which are basically motors that were modified and an internal blade was placed, to later be wrapped in a plastic chamber in which the water is transported:

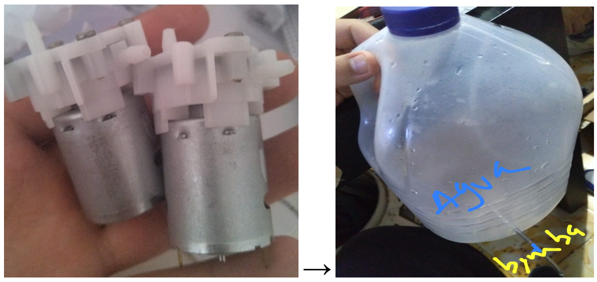


Image 34. Engines and water used for movement

With these motorized pumps, they were connected to a probe and later attached to larger syringes, hoping that the concept would be applied: The principle is simple, with the motorized pump, water will be drawn from a tank, this water from the tank must be equal to or greater than the amount that the syringe to which it is connected can store, so when it is dragged, Pascal's principle will be applied, reaching a small surface of the syringe, where a greater surface tension will be applied, generating a great torque and so on. to be able to move a certain amount of Kg, which to lift the arm of the umbrella, this needle must have the capacity to lift around 10 kg.

Image 35. Final physical model without the umbrella

With a defined concept and with the necessary materials, the syringe was applied externally, this in the form of a triangular support, because the mass point of the arm was considered, so that the application of force is distributed evenly. , and oppose less resistance, thus we obtain the result that you can see on the left hand side of this paragraph. Concluding that this is the most effective method to generate the necessary movement, in this prototype.

Image 36. Final model

Now the last thing that remains is to add the other syringe and the umbrella obtaining the result on the right hand side. Now if you want to see how the umbrella works, you can see it from the links below, remember that you must open it with the institutional account of the Autonomous University of the West.

link1: https://drive.google.com/file/d/1LOqOrnShmTcgKryFdF5QKeLhHeyZSGuB/view?usp=sharing

Link2:https://drive.google.com/file/d/16xiCEN-63z9H-2MDXtTPXgvaKHn2lLkQ/view?usp=sharin

VII. INDEPENDENT WORK?

During the development of this project, different sources were consulted on several occasions, which were used to be able to complete or add extra things to the project.

In fact, one of the most used sources was from The Construct, a virtual course platform, in which we learned many things and data, but what we used the most were the following entries:

“How to use Xacro files with Gazebo in ROS2”

“Spawn a URDF model in Gazebo with ROS2”

In these titles they explained to us the procedure to make a Xacro with Gazebo including the world and the modification of different elements such as dynamics, shocks, the generation of a xacro file in a simulation launch file, among others.

With this information it was possible to add the launch file of the Gazebo or Launch simulation together with the urdf in the same folder, which made it unnecessary to move between two different folders if you wanted to make a configuration either in the urdf or in the Launch of Gazebo greatly facilitating the organization of project folders.

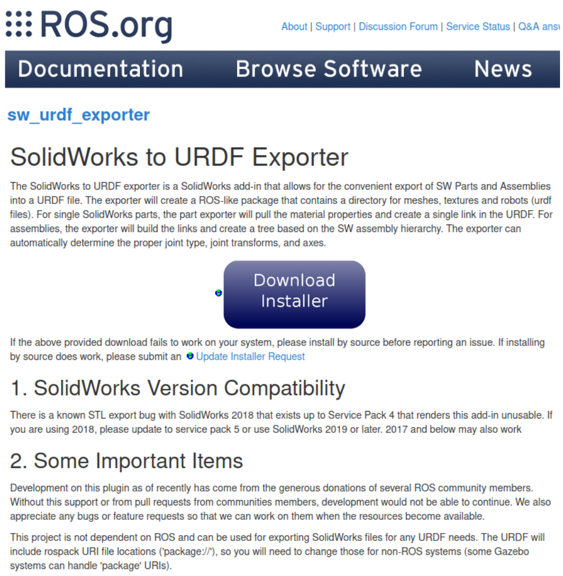
The second most used source was the ROS2 repository itself. At the beginning, when several problems were generated regarding the URDF, our greatest help was ROS2 Documentation: Foxy in the section on:

URDF Tutorials

And the first question was, why Foxy when working on Galaxy? The answer is simple, since foxy has a larger section of information than Galaxy, this is due to the time that each one has been published, Foxy being the oldest, in addition, our problem lay in the compression of the URDF, so these documents were very useful. to understand the operation and capacity of this file, it was thus possible to configure the movement limits of the umbrella, limiting the movement of the arm and the upper part of the umbrella, in addition to being able to add inertia and dynamics, since in the exportUrdf Solidwork does not generate any dynamic movement or limitation of links.

Another aspect but that seems irrelevant but very useful was that in these documents it was also possible to know the combination for different colors of the umbrella and although there were not many colors that we managed to find, at least the ones that we managed to get give it a different aesthetic touch. to the umbrella

The third source of information was videos about how to export SolidWork models in URDF format, for this section the main sources of consultation were YouTube videos, so some of the most used will be left in the bibliography. To download the URDF extension, a library called ROS.org was used, in which an article of an extension for Solid that exported in URDF was found.



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sw_urdf_exporter

SolidWorks to URDF Exporter

The SolidWorks to URDF exporter is a SolidWorks add-in that allows for the convenient export of SW Parts and Assemblies into a URDF file. The exporter will create a ROS-like package that contains a directory for meshes, textures and robots (urdf files). For single SolidWorks parts, the part exporter will pull the material properties and create a single link in the URDF. For assemblies, the exporter will build the links and create a tree based on the SW assembly hierarchy. The exporter can automatically determine the proper joint type, joint transforms, and axes.

Download Installer

If the above provided download fails to work on your system, please install by source before reporting an issue. If installing by source does work, please submit an Update Installer Request

1. SolidWorks Version Compatibility

There is a known STL export bug with SolidWorks 2018 that exists up to Service Pack 4 that renders this add-in unusable. If you are using 2018, please update to service pack 5 or use SolidWorks 2019 or later. 2017 and below may also work

2. Some Important Items

Development on this plugin as of recently has come from the generous donations of several ROS community members. Without this support or from pull requests from communities members, development would not be able to continue. We also appreciate any bugs or feature requests so that we can work on them when the resources become available.

This project is not dependent on ROS and can be used for exporting SolidWorks files for any URDF needs. The URDF will include rospack URI file locations ('package://'), so you will need to change those for non-ROS systems (some Gazebo systems can handle 'package' URIs).

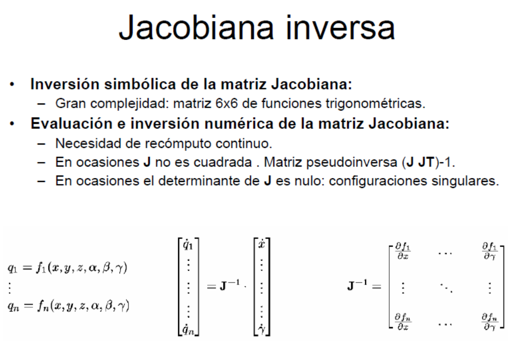
With the help of the guide offered by the page, it was possible to place said URDF extension for the SolidWork program, without this page it would have been impossible to be able to transfer our used model to URDF as we are new users in this world of ROS.

Finally, a source that was used but unfortunately was not applied was a book with the name of "ROS Robotics By Example", second edition in this book we learned about the nodes and the topics of Ros, learning node configuration, this allowed us apply and configure the necessary node to carry out the trajectory, we also wanted to include more functions but the book handles ROS and not ROS2 so there were many commands that we could not execute and we could not find their version in ROS2.

In addition to these sources, theses related to the subject were sought, such as the thesis "Development of an inverse kinematics solver for the manipulation of the Golem-III robot" by mechatronics engineer Eduardo Uriel Ortiz Sánchez, at the National Autonomous University of Mexico[6].

In that this thesis helped us in understanding the direct and inverse kinematics of the robot and how the steps were to be found, therefore also in the aspect of the relationship of use of ros and gazebo in operation in code as physical operation and how it is those devices connected to each other.

However, different forms and methods of making matrices already known in class were also consulted, such as the Jacobian, an interesting way of finding the direct and inverse kinematics.[7]



VIII. Discussion

This project was carried out taking into account several criteria according to the evaluation rubric of the Robotics subject, these criteria are:

1. Application of basic engineering principles to solve complex engineering problems.
2. Rigor in the use of the principles of science and mathematics to solve complex engineering problems
3. Credibility and updating of information searches
4. Relevance in the application of information

Now the main achievements that were obtained from this project are:

- Formulation of engineering, innovation and product redesign problems: It was possible to clearly and precisely analyze a problem to later be transformed into an engineering problem, in addition to a redesign process of said product, in this case the redesign of a umbrella in order to fulfill the same objective of a common umbrella, but following different routes, thus we meet the 1 evaluation criterion.
- Kinematic analysis of a robot from scratch and design calculations: During the resolution of the problem, different mathematical calculations were carried out such as direct and inverse kinematics, in addition to several simple calculations for the creation of a physical model, so from the point of view of the authors of this article, we can affirm that different principles of science and mathematics were applied.
- Search for various reliable sources: During the development of the project, various sources had to be used, so during the process it is always verified that these sources have a way to show their credibility with respect to the information displayed, that is why the sources observed in this article are of a professional nature, backed by proven studies, entities among other methods that certify the quality of the information.
- Use of collected information: This point is one of the achievements that was most used for the work, since at various times of the project it was necessary to resort to the manipulation of different third-party projects together with the information they provide to be able to apply in the case. that we are handling, clear examples we have the application of the knowledge offered by a work for the creation of models of direct and inverse kinematics. Or the modification of URDF files or Launch-type files, to adapt to the needs we had.

Thus we can confirm that throughout the development of this project the evaluation criteria were met in addition to the integration of knowledge, to provide the most realistic and effective solution possible.

IX. CONCLUSIONS

- The solution to the problem was proposed correctly thanks to the proper handling of tools such as the Gemma guide, which turns out to be very practical for the development of automated solutions, since it guarantees compliance with operating standards and allows a structured and flexible design that provides balance between the specific and general needs of the project.

- The analysis made it possible to highlight the importance of the verification marches, since at the time of validating the complete operation of the process, each movement can be observed slowly, which allows failures to be analyzed and ruled out at some point.

X. REFERENCES

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Annexes

In this section, a schedule will be left showing the activities and achievements achieved, starting in week 8 and ending in week 12.

	SEMANAS									
Actividades	8	9	10	11	12	13	14	15	16	17
Definicion de modelo a usar										
Modificacion y correcion del modelo										
Generar nuevo Launch del modelo										
Modificacion del Launch										
Comprimir Carpeta de proyecto										
Subir carpeta de proyecto a Git										
Generacion de trayectoria										
Modificacion de multiples trayectorias										
Implementacion de cinematica en el codigo										
Trayectoria generada a traves de cinematica										
Actualizacion de los archivos Git										
Video Pitch										
Entrega de Proyecto										