FTC 2016 - ResQ

The Gyroscopes Notebook

Team NL0069

I.I.S. “B. Castelli”, Brescia, Italy

Summary

T*he Gyroscopes - Team NL0069*

We are *The Gyroscopes:* for most of us, this is the first time that we take part in the FTC challenge, and we were all really excited and willing to do our best to create the best robot that we could. We joined the team in early November 2015, and started working shortly after.

Our team is composed of people with different skills that come from the wide variety of topics that are taught at our school, that can be very different from one another. Some of us study programming, others mechanics and automation, others telecommunications. We think about this diversity as one of our strenghts, being able to help each other and always learn something new that we may not get to study in our regular school courses.

Throughout the months that led to the competition in April, we tried to keep a regular schedule of two meetings every week to think about the project and start realizing our robot. Because most of us are near the end of high school and need to prepare for their final exam, sometimes we were not able to be together all the time, but we tried our best to spend as much time as possible trying to realize the robot that we hypothesized and wanted to use in the final challenge.

One of the most important things that we wanted to accomplish when working was to be as precise as possible: this led us to first creating each part of our robot in 3D before actually building it or realizing those functions that we could not have achieved just by using the Matrix kit. We also put a lot of attention in the details of the software, trying to refine it as much as possible to be able to control the robot correctly and easily.

Despite all of our efforts, we obviously ran into some problems: sometimes the ideas that we wanted to try were not effective, and we had to change them in order to achieve what we wanted, and we all obviously made some mistakes. But, in the end, everything ended up being a really interesting experience, that helped us learn a lot and create bonds between each other. As much as we had as our final goal to get the best result possible in the challenge, we also wanted to enjoy the time spent together and appreciate the project for all the teamwork that it involved.

We hope to get a good result!

The Team



Alekos *Filini*

Ettore *Gorni* **Laura** *Brognoli*



Luca *Franceschini* **Michele** *Treccani*

Giampietro *Busi*


Stefano *Gentilini*

Lorenzo *Borboni*

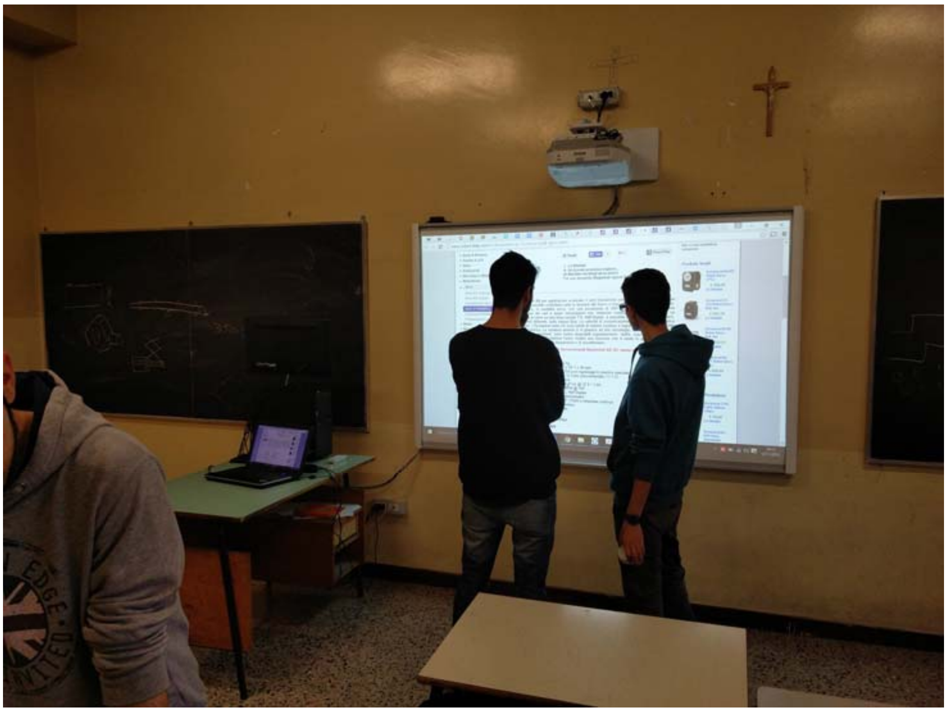

Andrea *Cassamali*

Nicola *Soave*

November 2015

The team activities to prepare for the challenge began in early November. During this first period, we mostly focused on defining the **hardware details** of the robot, to decide which precise components we should buy, and order them as soon as possible to avoid long waiting periods of time due to international shipping. We decided to focus on these aspects before starting to seriously develop the required software, thinking that having an already working robot and not an only hypothetical one was going to be more than helpful during the software testing phase.

The first meetings were scheduled and used to **organize the work** and **share ideas** about the project and the competition for the first time. After watching the introductory video together, we tried to understand what achievements we should try to accomplish to get the best possible score and how the robot should be designed to be able to suit our needs in the "autonomous" period of the challenge as well as the subsequent "driver controlled" period. During these first weeks, the work plan was still really confused and we often ended up going from one topic to another. However, this helped to create a "**brainstorming atmosphere**" which led to people sharing many and different ideas about the project.



The first important decision that we took, early in the design process, was to **use tracks for robot movement**. This helps the robot to be fast and makes it easier to climb the playing field "ladder". We also decided that it would be best to **keep the robot as light as possible**, to simplify hanging from the pull-up bar during the "end game” part of the challenge, one of the achievements that we instantly decided would be a good idea to accomplish. We hypothesized using some sort of “arm” for this particular objective, without immediately going into details.

For these last achievements, we thought we would need to use between 2 and 4 motors, to have enough power to correctly control the robot without having the need to have motors with multiple tasks. One of the things that we later took in consideration when deciding the **correct motors** model was if they were going to be able to stay still on the playfield ramp without breaking, at the same time allowing the robot not to slip down. This is obviously very important to allow us to be parked in the second part of the ramp at the end of the autonomous period, the best possible options that we thought we could achieve by using tracks, being unable to get to the last part of the ramp where we no longer have anything to stand on other than the aluminum bars.

The track model we wanted to buy was finalized pretty soon as well as the required track sprockets: we decided to use 2” wide tracks with 6-link sprockets. In order to have enough components in case we happened to break some of them during the testing phase, we thought buying an extra kit of both parts would have been a good idea.

December 2015

Next was a first attempt at deciding how the robot should move during the autonomous part. We instantly recognized the importance of **coordinating with the allied team** to decide who should press the “rescue beacon” button first, to avoid trying to do the same thing at the same time, and instead use these seconds to make the robot do something else. To make it easy to change the robot behavior for every possible situation, for example in case our partners decided to press the button or not, we thought that it would be best to have a single software that would allow us to decide, before the start of a single match, what should be accomplished in the autonomous period and in what order, to avoid any problems with the other team.

Regarding the rescue beacon button, it is obviously necessary to use a color sensor to be able to press the right button instead of the other team’s one. We also decided to score the preloaded “climbers” in the autonomous period of the challenge, and started thinking about a valid method to do so, without however coming up with any relevant hypothesis. The only thing we all agreed was that this would at least involve the use of one servomotor.

We also realized the importance of being able to move in the playfield without getting stuck due to the presence of debris, that we also needed to somehow collect. We first thought about having a “collector” that would close when the maximum number of collectable debris would get reached, without at the same time making the robot too heavy. In fact, collecting and moving in game debris was our next main point of interest. After thinking about how this task should be accomplished, we decided that this “collector” system would probably be the best and most effective idea. We decided to create a single, rounded collector with two moving panels on the sides, that is going to be able to hold 5 pieces of debris at the same time, the maximum amount that the rules allow. To gather these pieces, the robot is going to use a “moving-brushes” system, that will help to put them in the collector, whose left and right panel will be at this point closed. To release what is inside, the collector is going to be lifted and the panels opened, allowing for the already sheltered pieces to roll out due to simple gravity. Tilting the collector to help the pieces get out faster was another idea, but we decided not to think too much about it yet and maybe explore it if needed later in the buiding process.

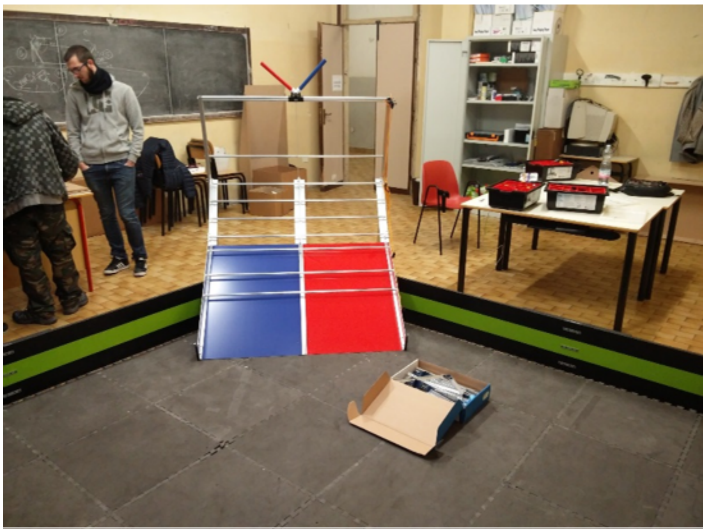
We all agreed that the robot should have the collector and the “pull-up arm” on opposite sides, to avoid making it too heavy on one side and too light on the other, creating a situation of imbalance that would result in many probles when moving. The software is going to allow the pilot to decide which side is the front and which is the back and also change them during the challenge, to make it easier to drive in both situations (when using the collector and when using the arm).

As weeks passed, thinking back about the ideas that we shared and the general design concepts that we agreed on, we finalized the number of hardware components that we needed to buy and created a precise "**shopping list**". In the end, not all the details about each part of the robot were definitively decided, because we realized that for some parts only **hypothetical thinking was not enough**, and we needed to try to build and consequently test the robot to see what achieved our needs : the main two aspect that we decided to leave for further thinking during the building phase were, again, the design of the arm that would help to hang from the pull-up bar and the debris shelter. Regarding the latter, another possible solution to the problem appeared, suggesting to use a belt-conveyor based system that would help the overall process of collecting pieces and releasing them more secure and stable: some memebers expressed concern with the old system being too fragile and possibly breaking during the match due to the high amount of moving part required to correctly use it.

Nome	Sito	Quantità	Prezzo (Singolo)	Prezzo (totale)	Spedizione	Totale
Kit Matrix	*Generation Robots*	1	199	199	15,8	214,8
Metà campo	*Andymark*	1	220	220	480	700
Cavi encoder	*Andymark*	10	5	50	0	50
Motori da 60	*Andymark*	8	28	224	0	224
Motori da 40	*Andymark*	2	28	56	0	56
Riduttore da 60	*Andymark*	2	12,5	25	0	25
Servo (Alette)	*Robot Italy*	3	13,37	40,11	0	40,11
Servo (Ribaltacassoni)	*Robot Italy*	2	34,72	69,44	0	69,44
Servo (Blocco motore sollevamento)	*Robot Italy*	3	57,22	171,66	0	171,66
Servo (Sportelli laterali)	*Robot Italy*	3	57,22	171,66	0	171,66
Servo (Forbice)	*Robot Italy*	3	57,22	171,66	0	171,66
Core power	*Modern Robotics*	1	80	80	80	160
Core Device Interface	*Modern Robotics*	1	58	58	0	58
Core motor controller	*Modern Robotics*	5	71	355	0	355
Core servo controller	*Modern Robotics*	2	63	126	0	126
Color sensor	*Modern Robotics*	2	34,67	69,34	0	69,34
Joypad	*Modern Robotics*	1	23,38	23,38	0	23,38
Batteria	*Pitsco*	3	50	150	0	150
Caricabatterie	*Pitsco*	1	34,95	34,95	0	34,95
Nexus 5 (?)	*Amazon*	2	280	0	0	0
ZTE Speed	*Ebay*	2	38	76	30	106
Cingoli	*Lynxmotion*	6	23,4	140,4	140	280,4
Route 6 denti	*Lynxmotion*	6	7,4	44,4	0	44,4

In the end, we were unable to define the precise number of needed motors and servomotors, and so decided to buy the max amount of motors plus extra (10 motors in total) and leave the servomotors for later. We realized that having motors was a priority compared to servomotors, and although we already had a decent idea of the correct number of motors we needed, the same could not be said for servomotors, and we wanted to avoid buying any unnecessary parts. Leaving the number of servomotors to be discussed in future meetings and not buying any of them just yet seemed like the wisest option. Anyway, we used a quite good amount of time to decide on the adapt model of both and also the batteries that we wanted to buy. We confronted many different kinds of hardware, trying to find the products with the **best quality at the lowest price**. Having a fixed maximum amount of budget, we wanted to spend the right amount of money to **avoid wastes** and possibly have the possibility to buy some extra parts in case we encountered problems during the building process. The shopping list also included the Matrix kit and the necessary motors and servomotors controllers, the sensors that we wanted to use, and the smartphones that we decided to buy to control the robot.

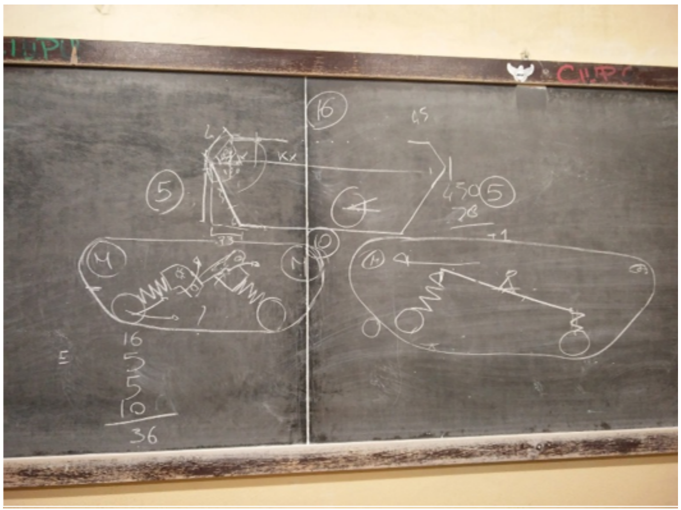
We ordered the pieces in the first weeks of December. Because most of what we ordered was shipped from America, at this point we only had to wait for everything to be shipped and arrive in Italy, hoping that it would not take too long. While waiting, part of the team worked on another project that we had to realize with the Lego Mindstorm kit to show at a **school event** where the FTC challenge was presented to possible future students of our school and members of our team.



The first part of what we had bought and ordered arrived just a few days before the beginning of the Christmas break, and the second package just before the end of the year. During the break, some members met at school to check if what had been shipped to us were the correct parts and if they were in good state, also spending some time to **mount the official competition playfield**.

January 2016

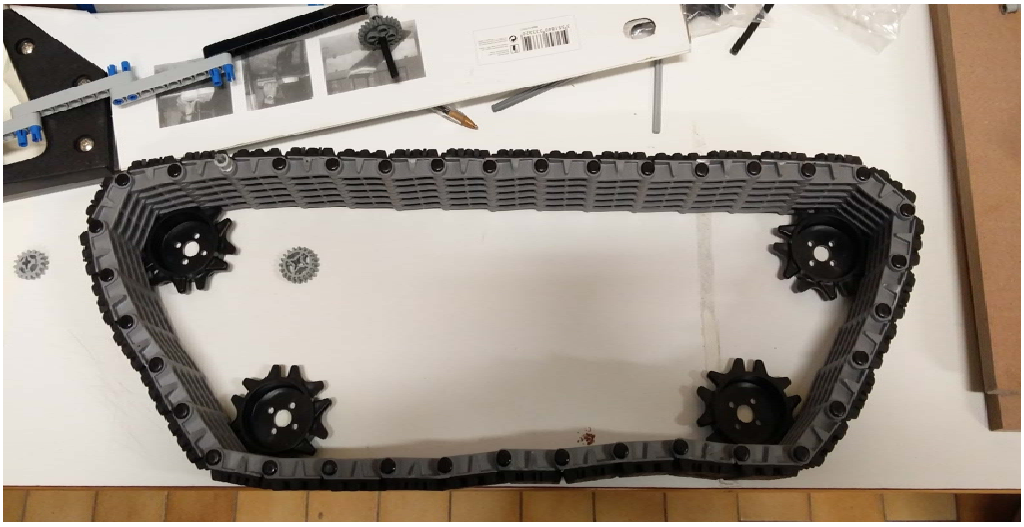
After receiving what we had ordered, one of the first things that we decided to do was to test all the motors to see if they worked correctly, and also to spend some time to **organize everything** that we had bought in different boxes according to what they should be used for: the new motors and the old servomotors that we already had went in their specific box, as did everything that had to be used in pair with the tracks, such as sprockets, and all the motor controllers and sensors.



The first thing that we tried to assemble and use were the **tracks** : we started creating a first, not too long line of track by assembling some of the multiple small track parts that we had bought. Because once these parts are correctly connected they become hard to disasseble, we decide to be careful not to create a line too long for now, to avoid having to remove parts in the future due to the line being too long for the final robots and possibly breaking the small parts. After creating a first prototype, we verified if it was able to move easily on the playfield, but even more importantly, on the ramp. We were **pretty satisifed with the performance** : the tracks moved swiftly on the playfield, and they were able to solidly stay on the ramp without any problems even without anything to apply pressure on them other than a really weak force applied by hands. We thought that later, with the completed robot, this would become even easier due to the obvious weight of the robot itself.

We obviously needed a basis where every other component and part of the robot had to be placed. Finally having the possibility to experiment with the actual robot parts that we were going to use, we first started hypothesizing the basis measures, and then tried to create it with a wood plank, shaping it as similar as possible to the final product we aimed to realize. The basis would be approximately 30x30cm horizontally with two vertical panels on two opposite sides, that we needed to use to attach some of the motors, particularly those that we were going to use to power the tracks. The basis would be realized in either carbon fiber or aluminum to make it light but resistant at the same time, to be able to hold every other part of the robot without breaking.

With the wood prototype realized, we decided to try to connect the tracks to it, to verify if the final product would actually work. The result ended up being **satisfying**, although because the wood basis was not perfect and the measures were not followed with extreme precision, the tracks ended up being a little loose. We agreed that this problem would not appear in the final version, because that would obviously be realized following each measure much more precisely. Anyway, this gave us the opportunity to finalize the lenght of the tracks, that were decided to be composed of 36 of the small tracks parts each.



Another component that we wanted to create a prototype of before the actual realization was the **debris collector**. This is obviously a very important part of the robot, because of how many points scoring the items in the correct zone of the ramp gives. We wanted this part to be functional and work correctly and possibly really fast to score as many points as possible. We were stil thinking about using the rounded collector described earlier in the design process, that would be lifted by a scissor-type lift placed on the robot basis to be able to release the pieces. This lift would be controlled by a motor installed on the basis too. In front of the collector, attached to the two basis panels, would be the rotating “brushes” to put the pieces in the collector.

We first realized a **carboard prototype of the collector**: this was created by hand and not by following the correct measures very precisely, because we only needed it to verify if the structure would be able to hold the amount of pieces that we wanted to, and if those would stay inside without moving too much or, even worse, getting out when we did not want them to. The structure was in fact effective, even without the side panels that we did not realize in cardboard, and so we decided to create another prototype, this time by printing it in **3D**. It took us a few days to get it done, but in the end were able to get an acceptable prototype, this time with the correct measures and side panels, too.

February 2016

Having the wooden basis and the 3D printed collector ready, we decided to assemble them, as well as the tracks, to test if everything worked correctly together. The only things that we initially did not attach were the tracks motor, because to have them placed correctly on the structure we needed some additional parts that we still did not have at this point.

Unfortunately, after some testing, we were **not really satisfied** with the result. The collector, in particular, seemed to be the part with the most problems: we were mostly concerned about the lifting, that seemed to be **unreliable and unstable**. Also, when the pieces needed to be released from the collector, it would be very hard to get them to correctly go into the playfield boxes. The first thing that we thought about to fix this problem was to tilt the collector gently, as already suggested before; this would require us to use additional hardware parts, as well as change the overall robot design to make this possible. But this was not the only problem: installing the collector into the wooden basis made us realize that it would be in the way of the tracks-controlling motors, that needed to be attached to the two side panels of the basis, in the same area where the collector would be lifted. To fix this problem, the only thing that we could do was to move these last motors in the rear part of the robot, and consequently use rear-wheel drive instead of front-wheel drive. This seemed to be a problem, in particular becuse we would need to use this system to climb the playfield ramp, and front-wheel drive would be better for this task.

In the end, we decided that it would not be a good idea to change these details to keep using the same parts that we already designed and tried, because this would lead to taking **too many compromises**. We thought it would be **wiser** to, instead, design a better, **more reliable system**. Fortunately, realizing the prototypes for these part did not take long, and we still had plenty of time to think and try something different that would work better.

At this point, the realization of the robot **software** also began. We were not expecting to come up with the final version of the software immediately, mostly because we were still in the design and realization part of many hardware components of the robot, but we felt like the situation allowed us to start creating at least a draft of what the application would be when we actualy had to use it in the competition. Most of the ideas that we had already **shared earlier** during our meetings were taken in consideration again and **discussed much more in depth**, and were used to create a **solid program basis** that we would later edit and improve to make it as close as possible as what we wanted to have as the final product.

Lego e robot diventano libri di scuola

Gioco e studio. Alcuni dei ragazzi impegnati ieri // FOTO NEG

L'iniziativa

Dai mattoncini colorati la creazione di modelli di micro-ingegneria

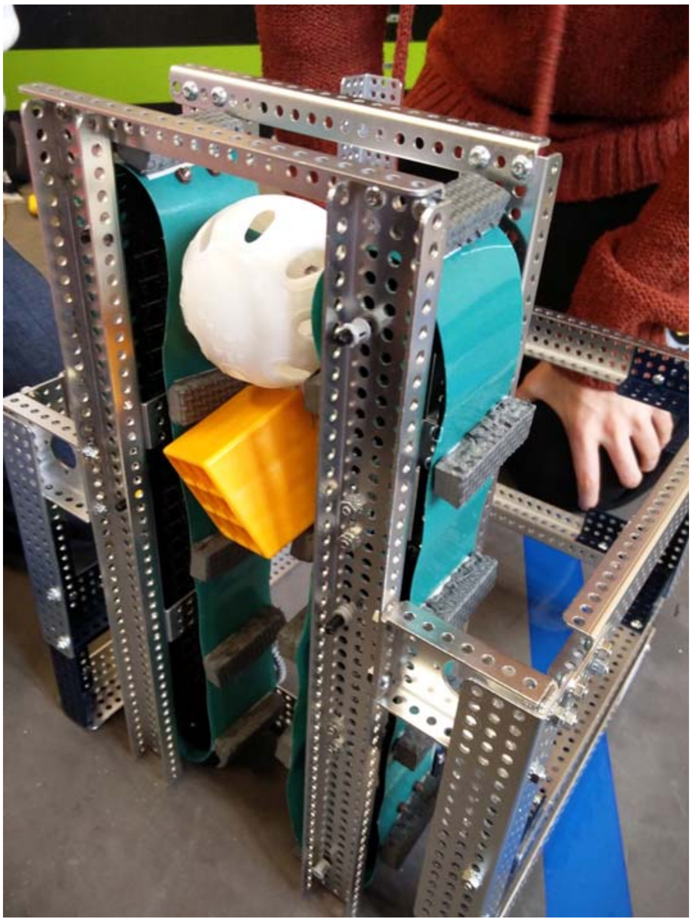
■ Chi non ha mai sognato di sostituire i libri di scuola con le costruzioni giocattolo? Il pomeriggio di ieri all'Itis Castelli è stato la prova che si può imparare (anche) giocando. Partire, per esempio, dai mattoncini colorati per arrivare a modelli di micro-ingegneria, unendo tecnica e creatività. Lego e robot al centro della scena, ma i veri protagonisti sono stati i bambini, o meglio, le famiglie: oltre 400 quelle presenti ieri all'istituto di via Cantore. Focus dell'iniziativa, organizzata dall'associazione Asd Dreampuzzle, la Junior First Lego League, prima edizione italiana creata sul modello dell'internazionale First Lego League, ma rivolta ai bambini tra i 6 e i 9 anni. Sei le squadre concorrenti, di cui tre bresciane, due bergamasche e una milanese. Ai partecipanti è stato chiesto di trovare soluzioni ecologiche per lo smaltimento dei rifiuti e di costruirle con i lego. «In questo modo - spiega Silvia Cerioni, di Asd Dreampuzzle - i ragazzini partono pensando di giocare, ma devono poi riflettere, progettare e quindi apprendere. Abbiamo organizzato questo pomeriggio per stimolare famiglie e insegnanti a portare avanti progetti di robotica formativa, soprattutto in una città industriale come Brescia, dove la conoscenza della tecnica può essere utilissima nel mondo del lavoro». Computer e costruzioni, fantasia e meccanica: sono nate così fabbriche di riciclaggio con tanto di presse e rulli, squali robotizzati per pulire le acque marine, smistatori e ruspe. Tutte le squadre di giovanissimi ingegneri, dopo aver illustrato al pubblico i loro progetti, si sono aggiudicate una coppa. Hanno invece partecipato singolarmente i concorrenti della Lego Creative, una gara-esposizione creativa pensata per tutte le fasce d'età. Anche qui non sono mancate le sorprese: dalla cameretta colorata costruita da un bambino di 4 anni al treno e l'aereo nella fascia 9-12, fino all'ascensore in movimento o la configurazione binaria a 8 bit, creati dai più grandi. «Ho sempre giocato con i Lego - racconta Enrico, 15 anni - e crescendo ho unito questo svago alla passione per l'informatica». C'è chi è andato o andrà lontano, come i dieci ragazzi del Castelli che ad aprile gareggeranno in Olanda per la First Tech Challange. Ieri erano presenti anche loro con alcune creazioni, tra cui la «mano bionica», un marchingegno fatto di lego e controllore elettrico, molto utile per afferrare oggetti a distanza. Non solo mattoncini, però. Tantissimi i laboratori ecologici, come quello per realizzare abiti di carnevale partendo da materiale riciclato o pesci colorati con bottigliette di plastica, carta e colla. Infine il drone, che ha volato nella palestra della scuola, rivelandosi congeniale all'apprendimento della fisica e della matematica. E tra bambini e adulti, chissà chi si è divertito di più. //

Ad oltre 400 famiglie con bimbi dai 6 ai 9 anni per la Junior First Lego League

CHIARA DAFFINI

We decided to start with the software that would be used in the driver controlled period of the challenge. We thought this would be an easier start because, in fact, we only needed to add controls for each function of the robot and decide which button on the joystick would be used for each of those. As expected, setting up the buttons did not take too long or much discussion, and for those functions that we still did not have on the robot itself, we just decided to wait and add new controls later. One of the things that we wanted to refine as much as possible was how the analog sticks on the controllers would be used for powering the tracks motors. We thought that going from one direction to another really quickly coul be problematic for those motors and, in fact, could end up damaging them. Because of this we implemented a system that, in case this happened, would make the motors go through some middle steps when going from a power value to an opposite one, hoping that this would help to avoid any possible damage.

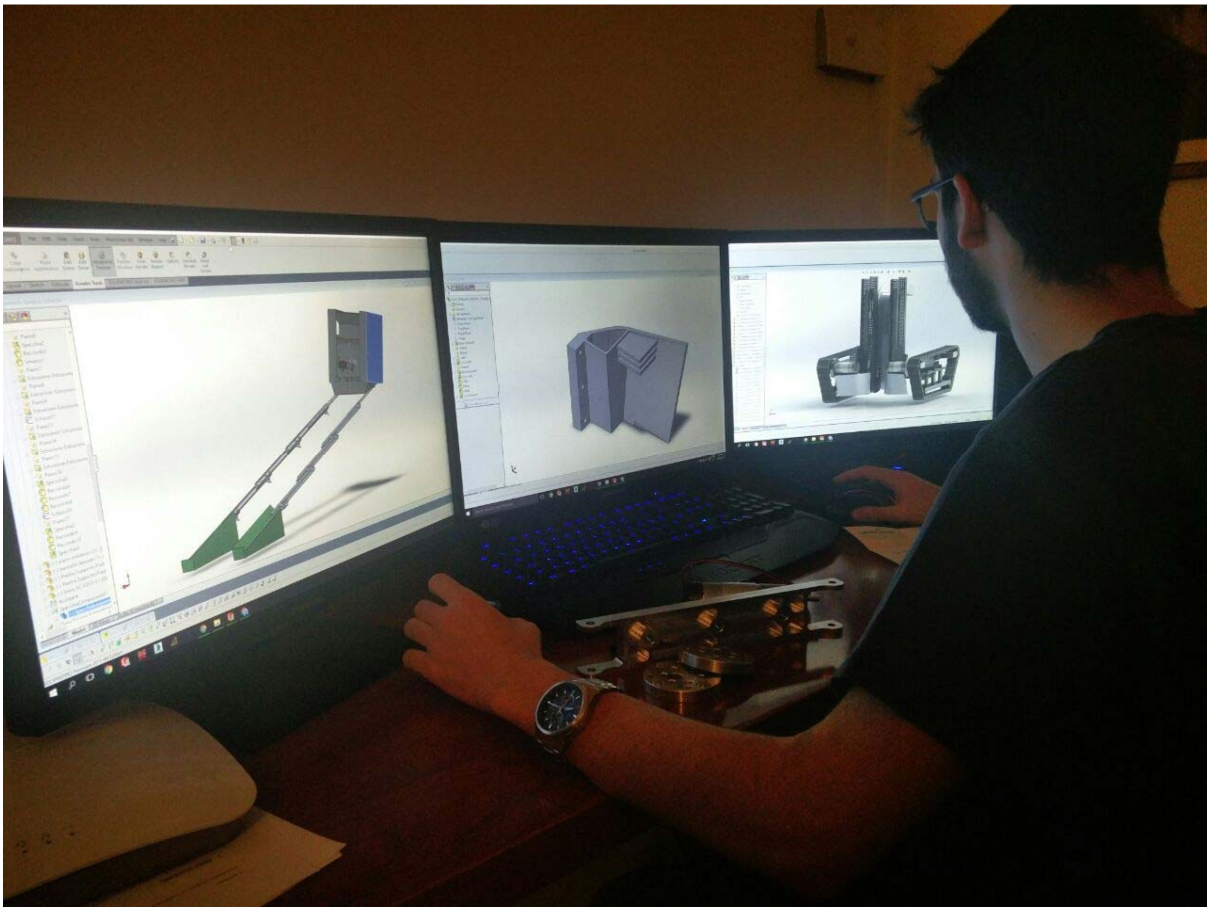
Meanwhile, having finalized the lenght and structure of the tracks, we started thinking about **suspensions** for the robot. The reason we decided to have suspensions was for two main reasons, the first being that they would help in case we happened to drive on some debris in the playfield, to avoid getting stuck or having any problems moving because of them. The second reason was to make climbing the playfield ramp easier: we were worried that without the suspensions, the robot would have problems to overrun the aluminum bars that are placed on the ramp. We thought that without those, the tracks would keep on spinning but never be able to actually move in the right way to go further. The suspensions were designed to be based on two plates with three springs placed between them, two at the edges and one in the middle, and realized in aluminum. The length and details of the springs were precisely defined to be able to suit our needs and, as many other parts of the robot, they were **customly realized**. In the final robot, they would obviously be placed in the tracks area and correctly attached to them.



As we had planned, we also started to design the new item collecting and releasing system that we were going to use. This time, we tried to make it **as solid and secure as possible**, to avoid the problems that we ran into with the previously realized and later discarded collector, that happened to be too problematic.
One of the ideas that we came up with and immediately tried to realize was an "elevator" system: this time, we decided to use some of the Matrix kit parts as well as some Lego parts that we customized to be able to achieve what we needed. The system would be composed of two vertical and parallel Lego tracks pieces, with some small sponge parts connected to it, each to a fixed distance from the other, to leave enough space to be able to hold one of the playfield debris between two of those. The tracks would be powered by a motor with a complex gear system attached to the Matrix kit parts that we used to hold everything together, allowing the tracks and the attached sponge parts to constantly spin almost at ground level.

The idea behind this system was to use it while moving in the payfield to collect debris by holding them in between the two tracks thanks to the little sponge parts, to dislocate them in a higher position and then release them in another area that would serve the purpose to gather the debris before releasing them, a task that we decided would be accomplished by another part of the robot, differently than the old collector that was used to both get and release the game debris.

This new system immediately seemed to be **much more effective and realiable**, and we were **satisfied with the result**, and also decided to keep using what we initially tought would only be a prototype as a final robot part. With this new system,one of the most important things is to set the motor that controls it at the correct speed, to avoid going too fast and possibly lose the pieces, or too slow, wasting a lot of time moving them. Anyway, although this new system happened to work fine with the square-shaped debris, we noticed it had some problems holding the spherical items correctly and sometimes was unable to move them from ground level to an higher level, and dropped them. This is mostly due to the fact that these last pieces are of different size and we obviously cannot change the position of the sponge parts constantly to fit one kind of debris or another.



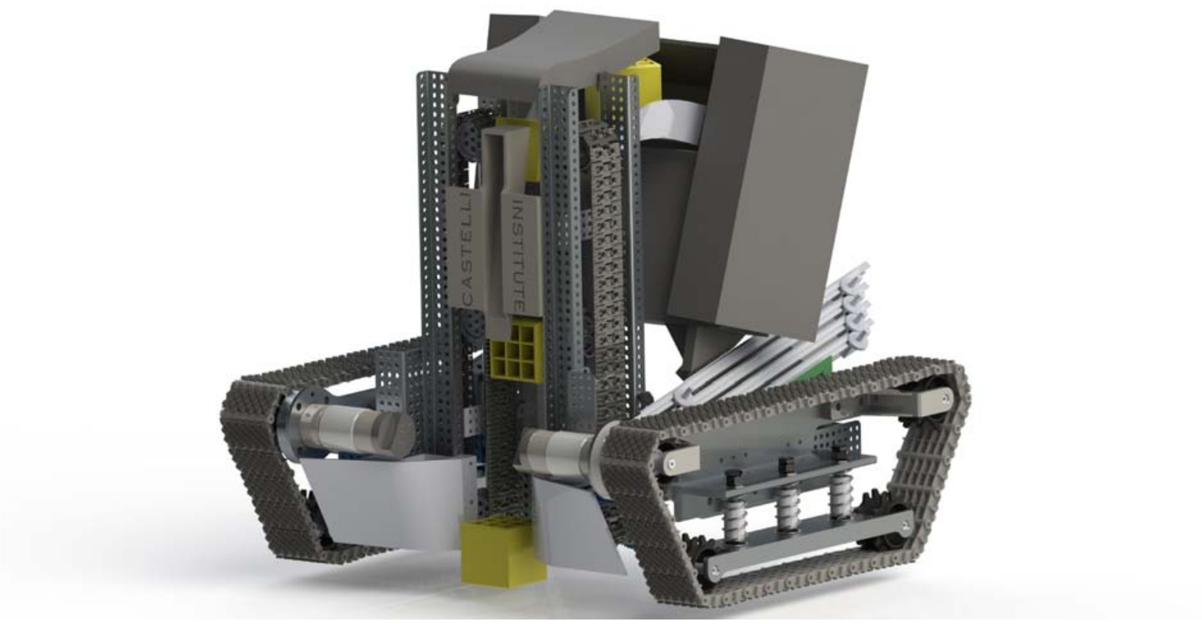
As said, this time we decided to have two different components for **moving the debris** and **storing them** before they get scored in the correct zone. After realizing the moving system, we obviously had to think about the new collecting and scoring system. What we decided to do this time was to realize a box-shaped component, that would be placed vertically on the robot, with the two long sides on the left and on the right that could be opened to let the pieces stored inside it fall out in the correct playfield ramp zone. All this system would be placed on two mechanical slides that could be elongated and shortened to move the box easily in the correct position without even having the need to climb the ladder every time. These slides would obviously be placed obliquely on the robot, to suit the ramp increasing inclination. After collecting the correct number of debris through the new moving system described earlier, that would let the pieces fall inside the new collector, we would elongate the slides to move it, to then open the panel on the correct side where we want to score the stored pieces. The panel would then be closed and the robot would be ready to go back to collecting new debris. Inside the box, we also thought about installing another small component that would move quickly left and right, to help the pieces that fall into the collector to spread correctly: the box is designed to be able to hold the maximum amount of pieces that can be controlled at the same time, and so if those pieces happened to fall on top of each other, it would then be harder to score them correctly. Having a fast moving system could help to avoid this by moving the pieces at random and increasing our chances of having them one next to the other instead of on top of each other.

Another component that we went back discussing in this phase was the "**arm**" that we intended to use to hang from the pull-up bar. We all realized how this is probably **the hardest achievement** in the whole challenge, and the number of points that it guarantees represents how difficult it is to accomplish it correctly. Throughout time, while discussing other parts of the robot, we shared many ideas about how we should approach this objective, but at the end they all seemed to be unsuccesful and not even worth trying to use them. However, in the end we were able to come up with an hypothesis that we, at least, wanted to try: the arm would be composed of a mechanical scissor system that would be elongated to attach to the pull up bar and then shortened to lift the whole robot. Obviously, this system has to be **very resistant** to be able to hold the whole robot weight, and needs to be controlled correctly to be able to actually attach to the bar and stay still while the robot is being lifted. We decided to try to realize it as best as we could and later try to see if it could actually be used, but we were not expecting it to be too effective and considered the idea of removing it completely if it happened to not work as well as we wanted it to.

These new parts, the collector and the arm, would involve the use of **servomotors**, and it was during this part of the design process that we want back to defining the precise number of servomotors that we wanted to use, a topic that we had decided to leave for later in the past to avoid buying any unnecessary component. Having a more realistic view of what the final robot would be and what the different parts would need to function correctly, we were finally able to finalize the number and models of all the servomotors that we wanted to buy.

March 2016

With all the components ready, what was left was to **assemble everything together**, **complete the software**, and **start testing** the robot to see if everything worked well and, in case, modify what did not satisfy us or we thought could be improved, and maybe add new parts that we realized could help us. Thanks to the precise realization of every component, that we were able to achieve by **having 3D models of everything** that we wanted to create, the assembly process was simple and all the parts connected easily to each other. What was left in the software realization was the code that would control the autonomous part and just a few controls for the driver controller period that would be used for those functions that were not in the robot at the time when the first draft of this part of the code was



created.

The software that would be used in the autonomous part of the challenge was harder to realize and required some time because of the number of **different factors** that we had to take in consideration to be able to use it in any possible situation. These factors included the color of our alliance and consequently the part of the playfield where we would start the challenge, our allied team behavior, and some others. But before even starting to write the code for this part of the software, we had to face another problem: the core device interface module that we had bought was not working correctly and when connected to the smartphones that we were planning to use it would not be recognized as active and properly working. Luckily, it got replaced quickly and so we were able to start coding again pretty soon.

One of the first things that we did when working on this part of the software was decide what we were going to do and in what order. We decided to press the rescue beacon button first, release the preloaded climbers and finally move in the parking area. Meanwhile, if possible, we wanted to try and collect some debris from the ground to be able to immediately score them in the proper zones as soon as the driver controller period began. We **carefully designed the path** that the robot had to follow to move correctly and accomplish what we planned to do and thought about the ideal route in case our ally decided to press the rescue beacon button too or not and, in case they decided to do, we also wanted to be able to decide whether we would do it before or after them, and so added the possibility to set it earlier in the software. The process of creating this part of the software required a lot of testing and hypothetical thinking to get every movement correct, the steering in particular. Because some of the measures on our playfield were only approximated, we were ready to later change the values for the movement after trying it on the official and more precise challenge playfield.

One of the problems that we ran into during the realization was correctly pressing the right button: this action required a really **high level of precision**, that we sometimes were unable to achieve due to some of the robot movements being really sudden and the fact that the color sensor appeared to be reliable, but still made some mistakes and sometimes was unable to correctly identify the color of the button. As we tested this function more and more, we decided that it would be wiser to see how it would work on the official playfield before ultimately deciding to use it or not, to avoid any possible problems that we would be unable to handle correctly at that point.

Unfortunately, just a few days before the competition, the company that was realizing the new item collector that we needed to build on the final robot, warned us that they would not be able to complete in in time. This was the only part that we were still waiting for and had not tested yet, so this immediately appeared as a problem, because we had to directly realize it ourselves and it would obviously be of lesser quality. With just a few days left, we started to build this component hoping that it would not take too long and that we would be able to test it correctly with the limited amount of time that we had left. Meanwhile, we decided to **focus on testing everything else** and **fixing all the small issues** that we expected to appear during the testing phase.

Testing was, obviously, the final and most important part of the work, and the moment when we would finally see if everything that we had realized and worked on for so long would actually function correctly and suit our needs. We were immediately satisfied with the robot movement, although at first glance it appeared that one of the motors was broken, and one of the two tracks was not moving. Luckily we soon realized that this was due to this last track not being correctly attached to the motor itself, and we just had to put the two components in their correct position. However, one thing that disappointed us was discovering that our robot had serious problems overcoming the aluminum bars on the playfield ramp: correctly moving over them appeared to be extremely hard and dangerous, as it could even overturn the robot itself. Still, **the robot could easily be parked on the first part of the ramp with no problems,** and this issue would not make it harder for us to unload the collected debris thanks to the slides-based system. The “elevator” system to move the debris worked well too, but as expected it still was unable to correctly move the round-shaped pieces, that we finally decided to ultimately ignore in favour of the square-shaped ones.We spent some time **finalizing and testing the code** too, in particular the part that would be used for the driver controlled period, that was updated to adapt it to the functions that were added or changed since the previous updates.

One thing that we had to take in consideration in ultimately defining the structure of the robot was the position of the various devices needed to control the motors and servors, the battery, and the smartphone too. We decided to close the space that was left open under the slides by placing a small wood plank to use it to store the battery. As for the controllers, the best option seemed to be to attach them to the front and rear part of the debris moving system, where there was a lot of space that could be used, and it would also help to keep the debris from falling off. Just a few days before our flight, we were finally able to get the final part that we were still creating, assemble it on the robot and test it.

In the end, we were **happy** with the final result. We were still waiting for the last part to be completed to test it, but we were **pretty confident** that it would work well enough to fit on the final robot, that at this point we had the possibility to test enough to consider ourself satisifed. Although the final result was not perfect, and we were not able to achieve everything that we hypothesized to do when we first began the design process, we were still happy to complete the project and **proud of what we had created**. The whole experience had been interesting for everyone, and we all got to learn something new and experience something that we had never done before. As much we wanted to get the best possible result in the actual challenge, we also realized that **the important part of the whole experience was, in the end, the experience itself, the time we spent working together, the ideas we shared, the relationships we created between each other**.

With this mindset, we were ready to go to the Netherlands and take part in the final challenge.