Beyond Brainstorming
“What to do when your ideas fizzle?”
for FLL and FIRST

By

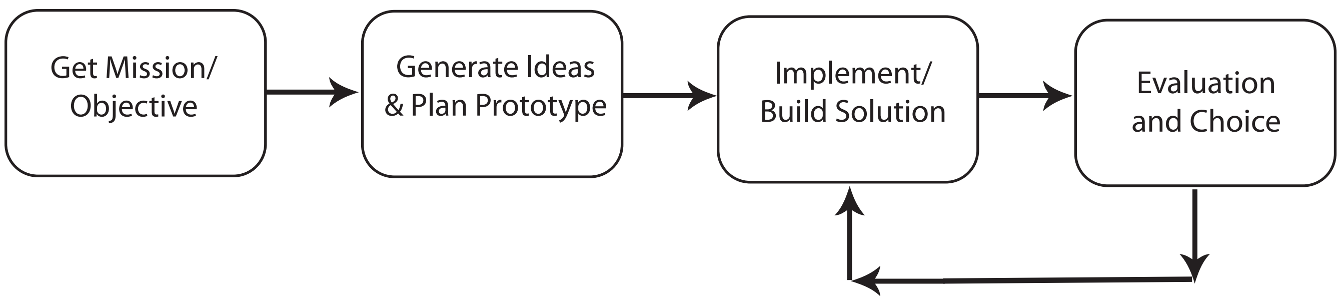
Kung-Khoon (K.K.) Quah

Background

I have been a coach for 3 years in the FIRST LEGO League tournaments and one of the weakest areas remains a good structured approach to problems solving that will yield results. Some of it is the obvious maturity of the team members from 9-14 years old. However, other factors I believe are important which is that most students are NOT taught any approach to problem solving. So we have a tournament which is essentially all about problem solving and yet most participants may not be familiar with techniques of creative problem solving. There are many BUT here are a few that I have found to be practical in coaching a team.

Abstract

Would like to present the typical problem solving process that a team goes through in solving for an FLL mission. Then present some different practical techniques for generating ideas to solve the missions. I will use LDraw names for the LEGO® pieces described. Since I coach FLL, all anecdotes and examples from FLL.



Typical Problem Solving Process in FLL

<u>Component Problems of Each Mission</u>

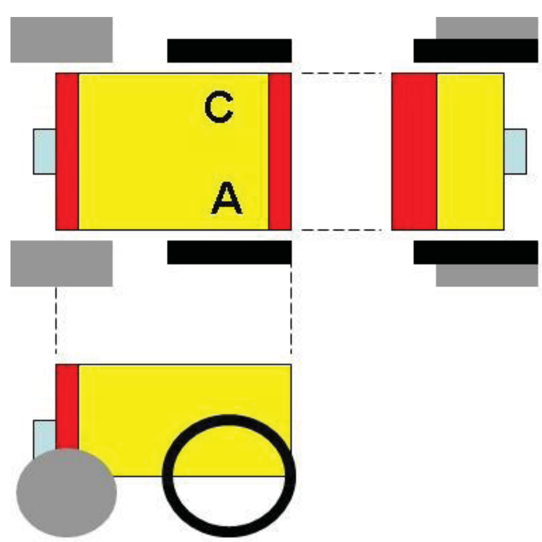
In one approach you can view each mission as 3 components

- Get the robot to the target area
- Deploy the manipulator
- Get the robot back to base

The first and third are linked as they are dependent on the capabilities of the robot. There are times that you might not return the robot to base e.g. if it is the last mission to be attempted.

<u>Where do You Start?</u>

First, the team must build a robot and decide on the features of the robot so your assumptions about the robot capabilities are known and stable. Then you can start with solutions using manipulators. You need to look ahead as there might be a mission that requires climbing up a very steep slope so that a robot that is not geared down enough will have to change the gear ratios.



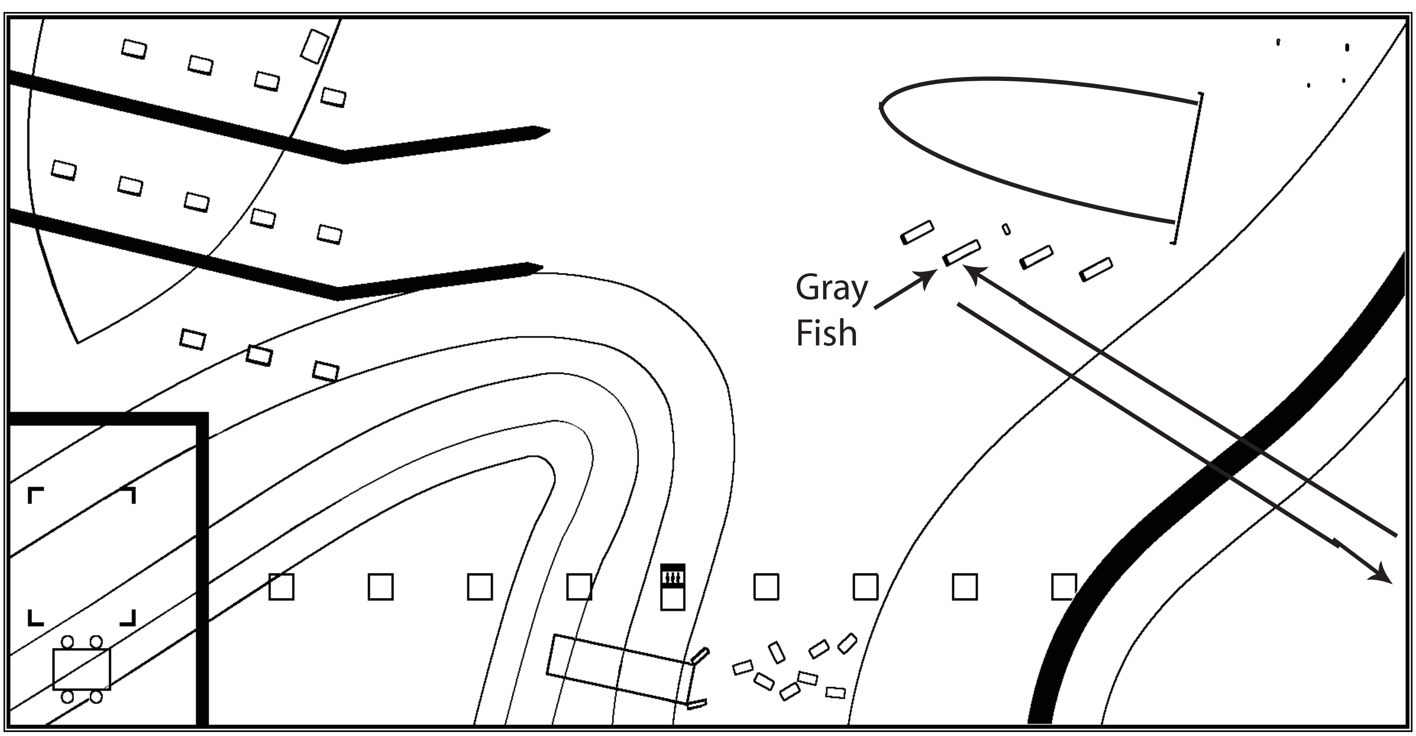
Let's assume we have a simple robot with 2 motors, one each side (motor A and motor C) with a light sensor in the front. The back wheels are the Wheel and Tire 81.6x15 Motorcycle and the front uses just the Motorcycle Wheels. The red areas in the front and back can easily hold manipulators. There is a rotation sensor on the axles of the wheels to allow for farily precise forward and backwards motion. However, this robot uses timing for turns so that is its main weakness.

Planning Prototypes
In planning the prototype, I usually like to think of the 3 “P”s which are path, program and pieces. The path is the most important item to work out as it determines how to get your robot to the target area or where the action will take place. The path usually then dictates the program. Simple paths will have simple programs and more complex paths will have more complex porgrams. Finally when the team is able to get the robot to the target, then the design of the manipulator to deployed determines the pieces used.

The area where I will be concentrating the rest of this article on is in the intial design of manipulators and the refinements a team has to go through to make the deployed manipulator reliably solve missions. There may be times when the design of the manipulator may cause a change in the design of the robot but if teams plan ahead, there should be few issues there. A typical example might be the manipulator may need to be attached at a specific point on the robot that necessitates creating areas of attachment or moving pieces so that the manipulator can be accomodated in a particular location on the robot.

Design Expectations
I like to set up expectations that hopefully will result in more efficient ways to get at alternatives and better peer review of alterntives and solutions. It can be summed up in the following useful quotations:
“The initial answer is usually NOT the best.”
“There is always room for improvement.”
“The plan may be useless but planning is essential.” – Eisenhower
“How do you get to Carnegie Hall?” Practice(3x). “How do you evaluate a model?” Observe(3x).

Sample Species Mission
Let’s look at some missions. The figure below is a top view of the FLL 2005 competition mat which is 4 feet by 8 feet with mission elements on it. The Sample Species Mission which has the objective of tagging the gray fish while leaving all the green fish untouched. The path is a simple one with a straight line from base at an angle and after tagging the gray fish only (second from the left), to return to base by reversing the motors or going backwards. Starting solution does not have to be complicated. I encourage the simplest – a simple stick (extended axle).



In this simple mission with 2 iterations from the initial solution, we manage to get to a fairly robust solution.

Initial Solution

Issue:

Need better contact with target

2nd Solution

Issue:

Too hard contact with target

Final Solution

Desired effect:

Soft contact with target using
Hose Flexible 8.5L without tabs

However, here's another point of view of the fishes to generate more ideas. The gray fish at its highest point is 3 plates (shown by the white and black plates below) higher than the green fish. Manipulators that are positioned high could easily move the gray without disturbing the green fishes. This would have the advantage of not needing as precise a manipulator to contact the gray fish.

Let’s look at some techniques for generating ideas.   Here are 6 techniques that can be used in coming up with alternative ideas.

How Do You Get the Next Idea/Alternative in Iterative Process?

Analysis of Past Solutions (should be the first choice)
Brainstorming (likely the most effective and common technique, good for groups)
Brainwriting (variation of Brainstorming, good for groups)
Attribute Listing
Morphological Analysis (variation of Attribute Listing)
Orthogonal Thinking (borrowed from business strategy class)

Analysis of Past Solutions

For veteran teams, look at previous missions that have a similarity to current mission and see what you have tried in past years. Choose that as initial starting point and start iterations. For new teams, attend local and state competitions to learn from the other teams.

Brainstorming

Was invented by Alex Osborn of the advertising firm of Batten, Barton, Durstine and Osborn to increase the quantity and quality of advertising ideas. Called “brainstorming” because participants’ brains were used to “storm” a problem. Usually groups offer up alternatives verbally and spontaneously which are then written down.   Wild ideas encouraged and quantity is paramount.   Ideas then sifted through and evaluated by the group.   Usually rules and expectations are set up front – most common one is that “Suggestions are not pre-judged”.

Brainwriting

Similar to brainstorming but nonverbal.   Participants sit in a circle and write down ideas which are then passed clockwise to neighbor and other ideas are piggy backed on for specified time.   Possible 2-3 exchanges are made to generate many ideas.   Advantage of the leader not being too influential but it is less spontaneous than brain-storming.   Presumes good communication skills (also good hand writing skills)

Attribute Listing

Developed by Professor Robert Platt Crawford of the U. of Nebraska.   Start by listing all attributes or qualities of a problem or object.   Systematically analyze each attribute or group of attributes and try to change them in as many ways as possible. Then review the resulting attributes for practical and best solutions.

Example

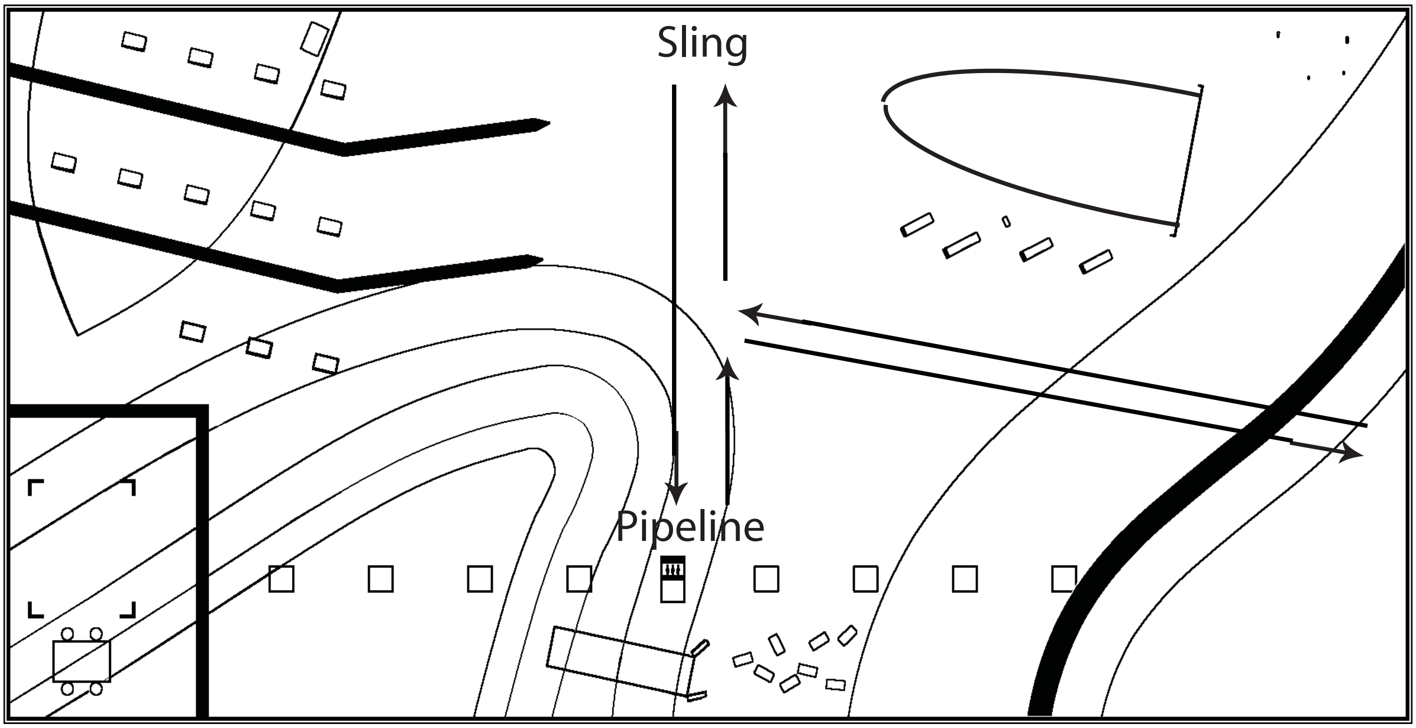
In the attributes listed below, some possible changes are in the brackets.   So test each of the changes to see if something needs to be done for a particular attribute.   Applying this to the Sample Species mission, we changed the Contact Region attribute from a point of contact to a longer line of contact in the second solution. In the final solution, we changed the Impact with Target from hard to soft.

Manipulator Attributes

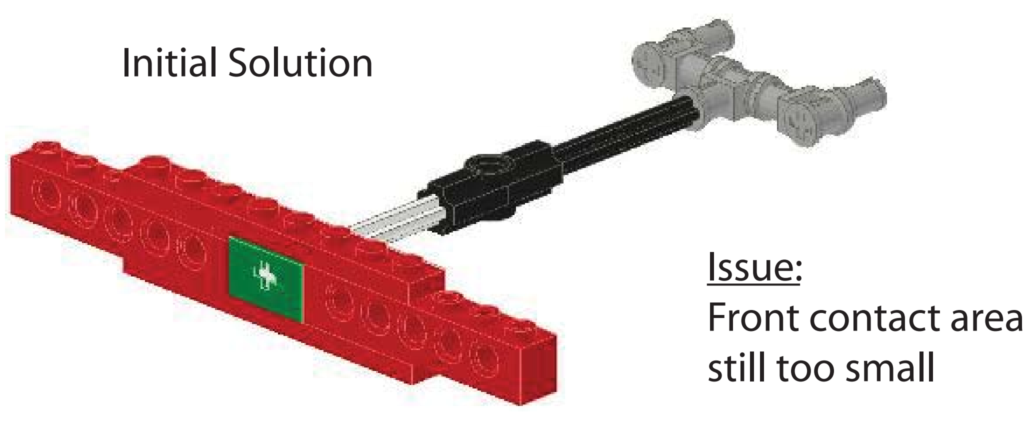
- Dimensions – length, width, height (increase/decrease)
- Weight - payload (increase/decrease)
- Attachment Point to Robot (right/left, front/back, top/bottom, at an angle)
- Sensor triggers attachment (yes/no) If yes, will you use light sensor/touch sensor.
- Impact with Target (hard/soft)
- Contact Place on Target (right/left, front/back, top/bottom, at an angle)
- Contact Region with Target (point, line, area)

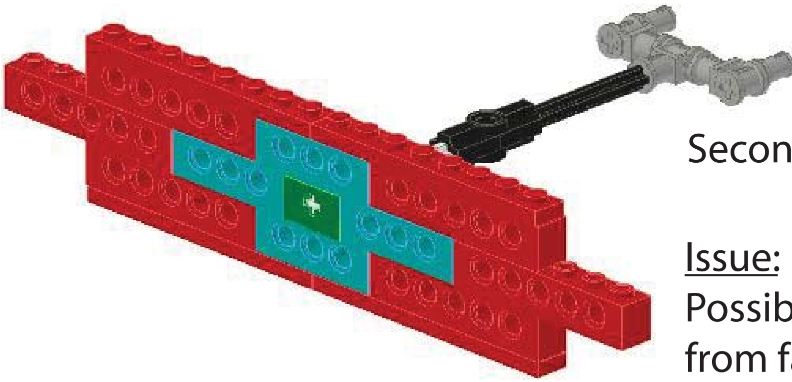
Dolphin and Pipeline Mission,

The objectives of these missions are to free the Dolphin from the sling and to install the missing section of the pipeline. The first is accomplished by using a front manipulator (like a bumper), then back up and push the missing pipe piece to complete the pipeline using the back end of the robot as a back bumper. This path is a more complicated one with a straight line from base at an angle, then a right turn and stopping appropriately after it hits the sling, then backing up perpendicular to the long edge of the table until it hits the pipeline, moving forward again a short distance before a final right turn and forward to take it back to base.



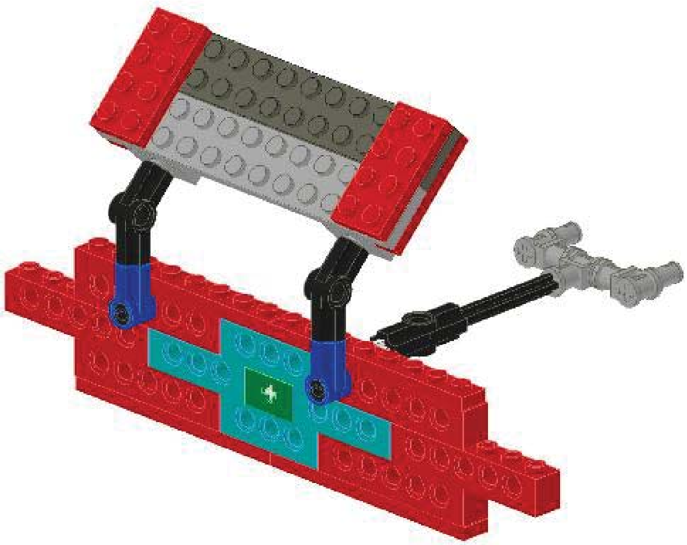
The initial solution was arrived at quickly with just a simple bumper made of beams. As an extreme case of always starting with the simplest, if they started with just the extended axle, an interation would have added the front bumper to have better contact and a second iteration might have modified the back attachment point so it has 2 pins to attach to the robot front which will improve the stability of the bumper.





Second Solution

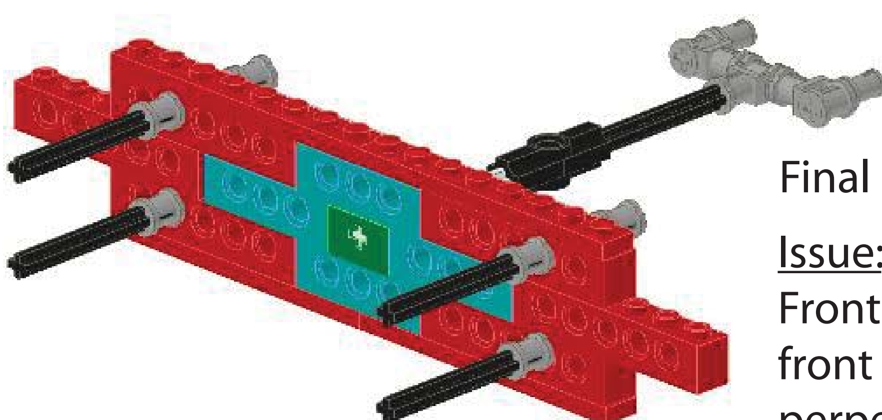
<u>Issue:</u>
Possible interference from fallen Dolphin



Third Solution

<u>Issue:</u>
Sometimes front not perpendicular to long table edge.

Although the team developed a “Dolphin Catcher”or deflector, this was ultimately not used as the rules allowed teams to ask the table refrees to remove the dolphin after it was freed.   And the deflector would have added to the weight of the manipulator.



Final Solution

<u>Issue:</u>
Front axles will help front become perpendicular

Looking at the path, the first right turn is important because if made incorrectly, then the robot path will not be perpendicular to the long edge of the table.   Our robot uses a timer in Robolab to make turns which is not precise so using this four axles will make the robot square to the edge.

Morphological Analysis

This technique was developed by Fritz Zwicky. It uses a matrix where the items on the horizontal axes are again attributes (factors, objectives in other problems) and on the veritcal axes are characteristics, adverbs, adjectives, prepositions, etc. Then we try to force one set of characteristics against another to create new ideas that can be used. Choice of the characteristics is important as you want those that can give you new insights. The big advantage of morphological analysis is that it generates a lot of ideas in a short time.
You can use this in a group or first do it individually, then develop a pooled matrix.

Morphological Analysis Table for FLL Manipulator

	Adapt	Modify	Duplicate	Add to	Increase	Decrease	Substitute	Rearrange	Reverse	Combine	Yes / No	Switch Side	Take apart
Length													
Width													
Height													
Weight													
Attachment Point to Robot													
Sensor Triggers Attachment													
Impact with Target													
Contact Place on Target													
Contact Region with Target													
Path to Target													

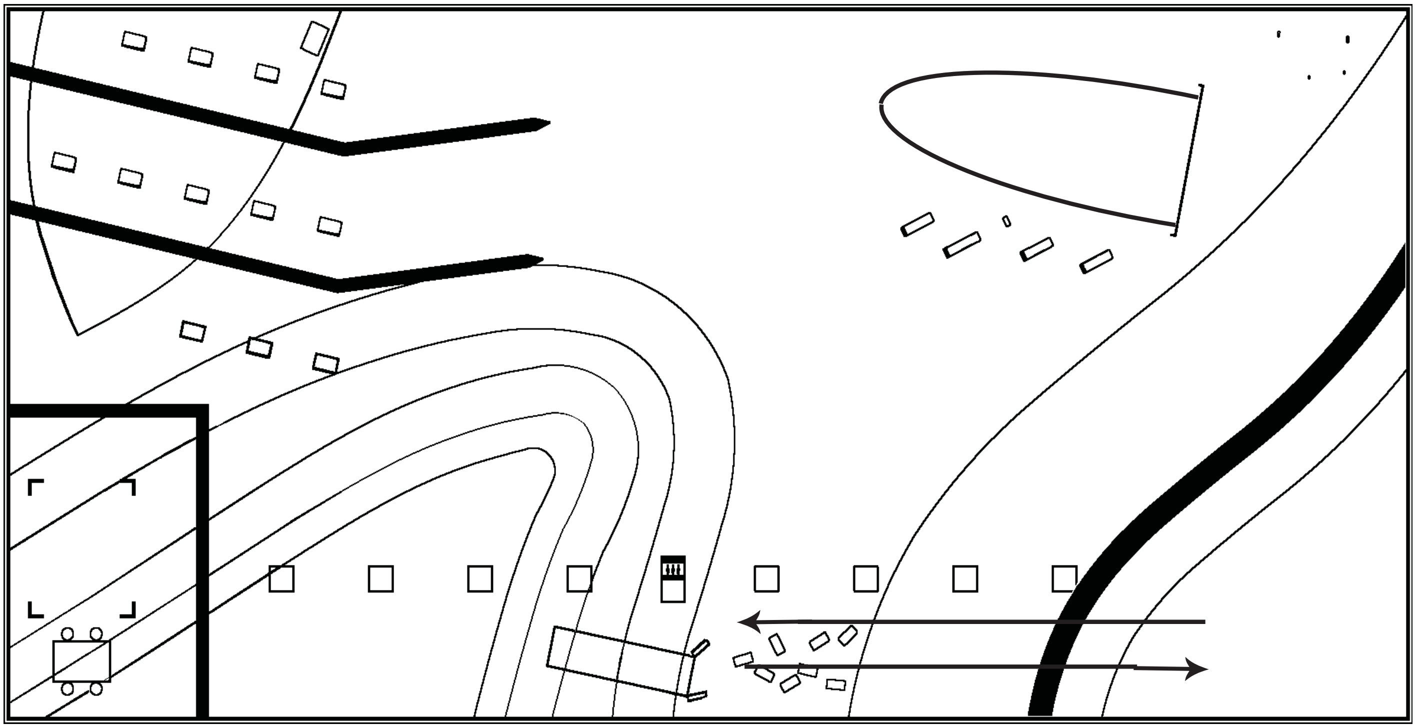
Orthogonal Thinking

This is one of my favorite ways of generating ideas. I remember using this in a business strategy class. The idea is to look at the opposite elements in a particular corporation to try to discover what the new business can become or what it might be missing. For instance, in the class, it talks about whether the business vertically integrated or is it horizontally stratified? Does it sell goods to the public sector or the private sector? Is the income from the business fixed fee based or a commission based? Then we talk about whether the corporation needs to go into areas it is not currently involved.
So the idea is to deliberately look at the opposite elements of how you are approaching a problem to see if it can get some insight into a new approach. Roger von Oech talks of reversing your viewpoint and writes, “Doing the opposite of what’s expected can also be an effective strategy in competitive situations such as sports, business, warfare, romance, etc.

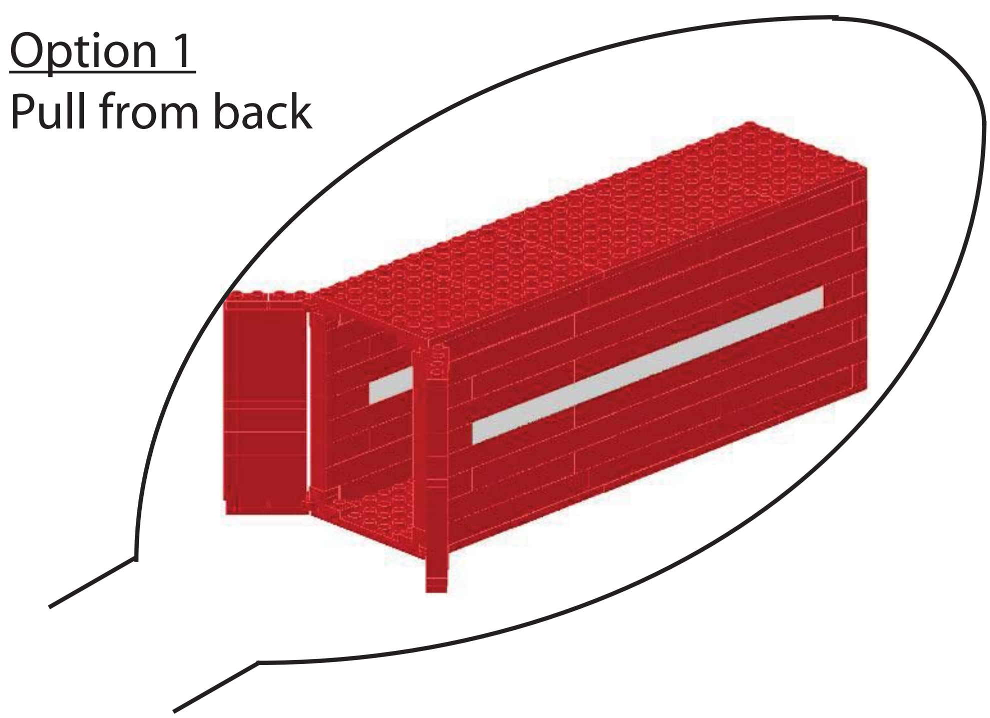
The mission that the team had the most fun with this technique was the Container and Cargo Mission. The team found that looking at the orthogonal elements was helpful i.e. push v. pull, back v. front, outside v. inside. This led to various options to try out and evaluate.

Container and Cargo Mission

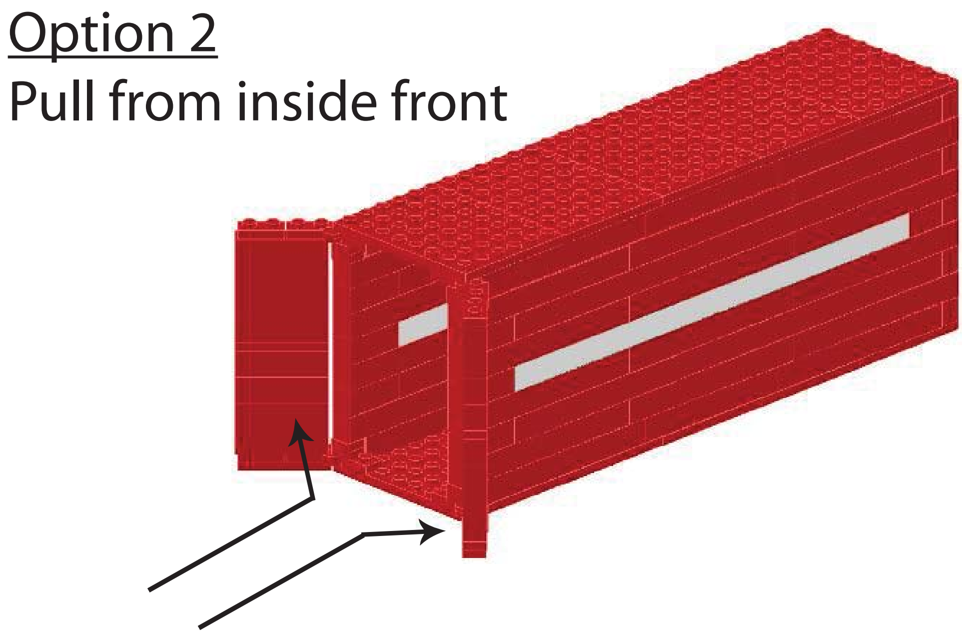
The objective here was to get the container and cargo boxes back to base. Let's ignore the cargo at this point. The biggest problem was the container which was a heavy payload to return to base. The path from base is very simple and noted below.



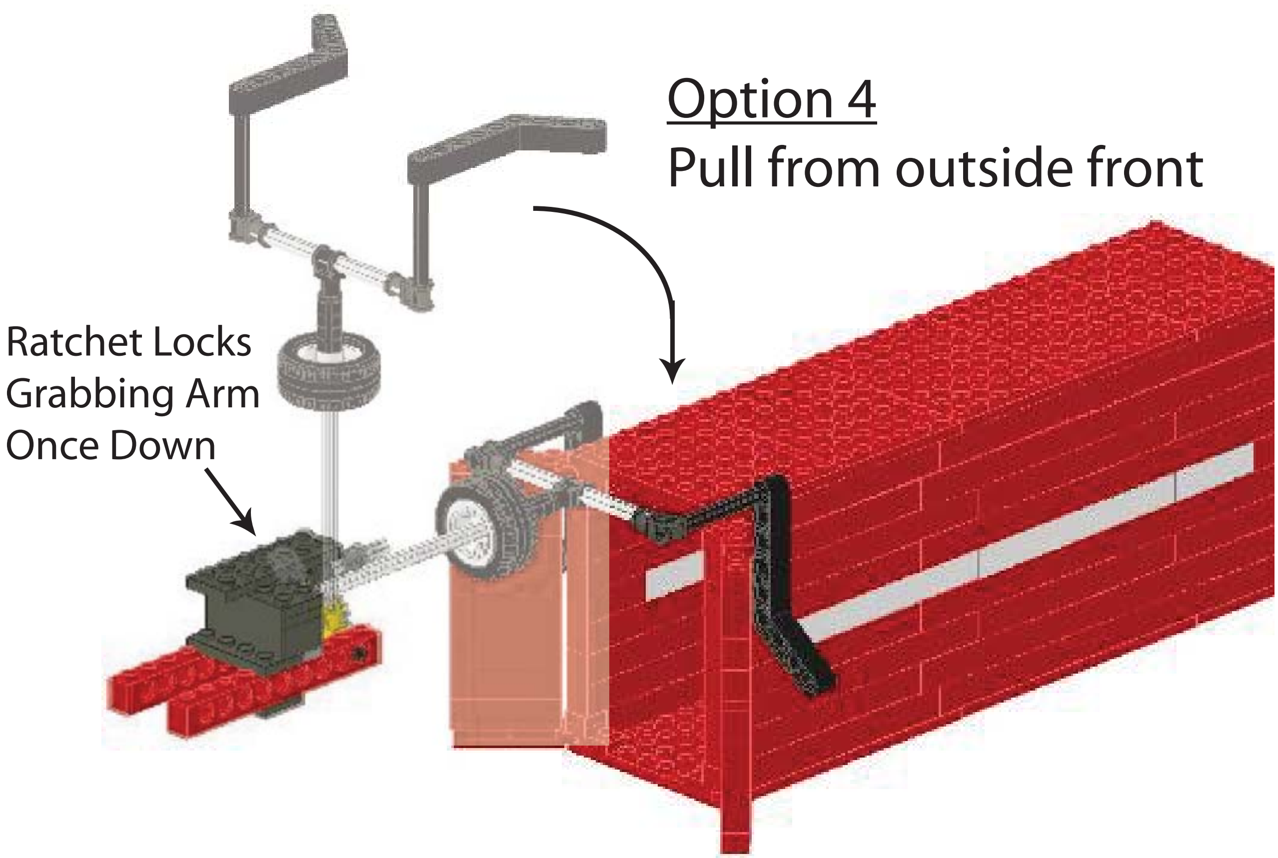
The first option is to get a long "lasso" to drop around the back of the container so we could pull it into base. Some issues were that the lasso needed to be light and could not exceed the 18" height limit for any manipulator on the robot. Also, the lasso had the tendency to slip off the back because of the heavy weight or sometimes would not deploy properly.



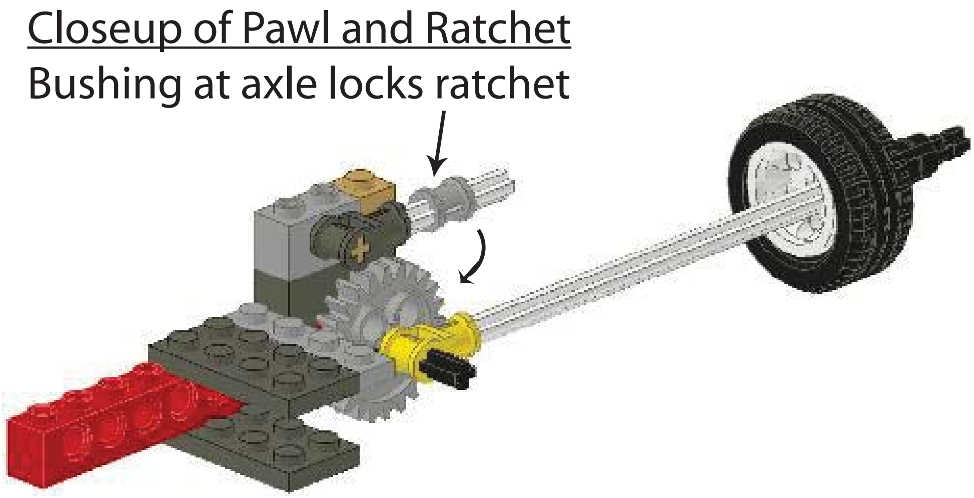
The second option was to consider some mechanism to grab it from the inside front of the container. The mechanism was fairly complex involving worm gears and a motor and only worked half the time. It was also harder to reset to make trials.



The third option that worked and was most reliable was to have a mechanism to grab it from the front. Again the weight of the container is an issue so there was a tendency for the forked grabbing arms to slip up and off. However, a pawl and ratchet built into the drop down mechanism overcame this issue.

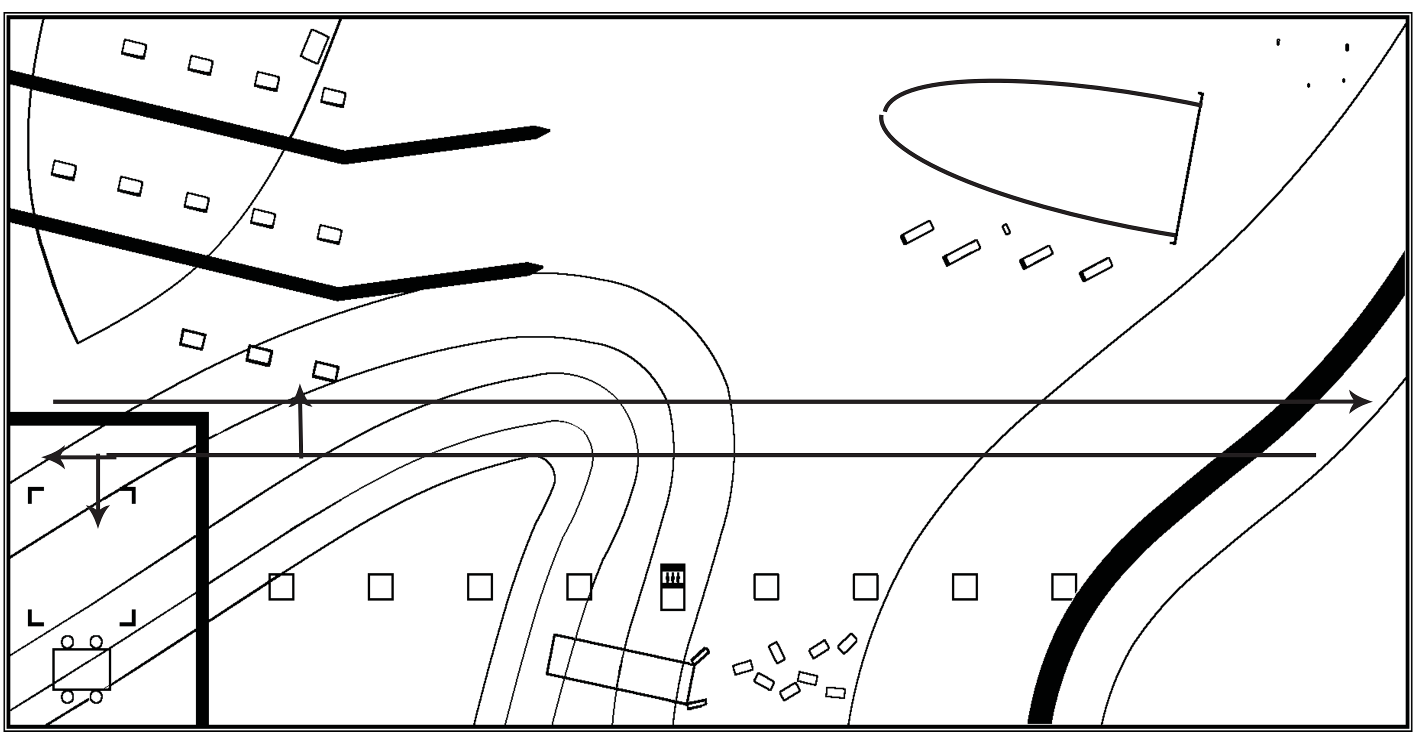


Here is the closeup of the ratchet with some pieces removed to show how the mechanism worked. As the large grabbing arm fell, it would drag on the bushing noted below which acted as a pawl to the 24 tooth ratchet gear.



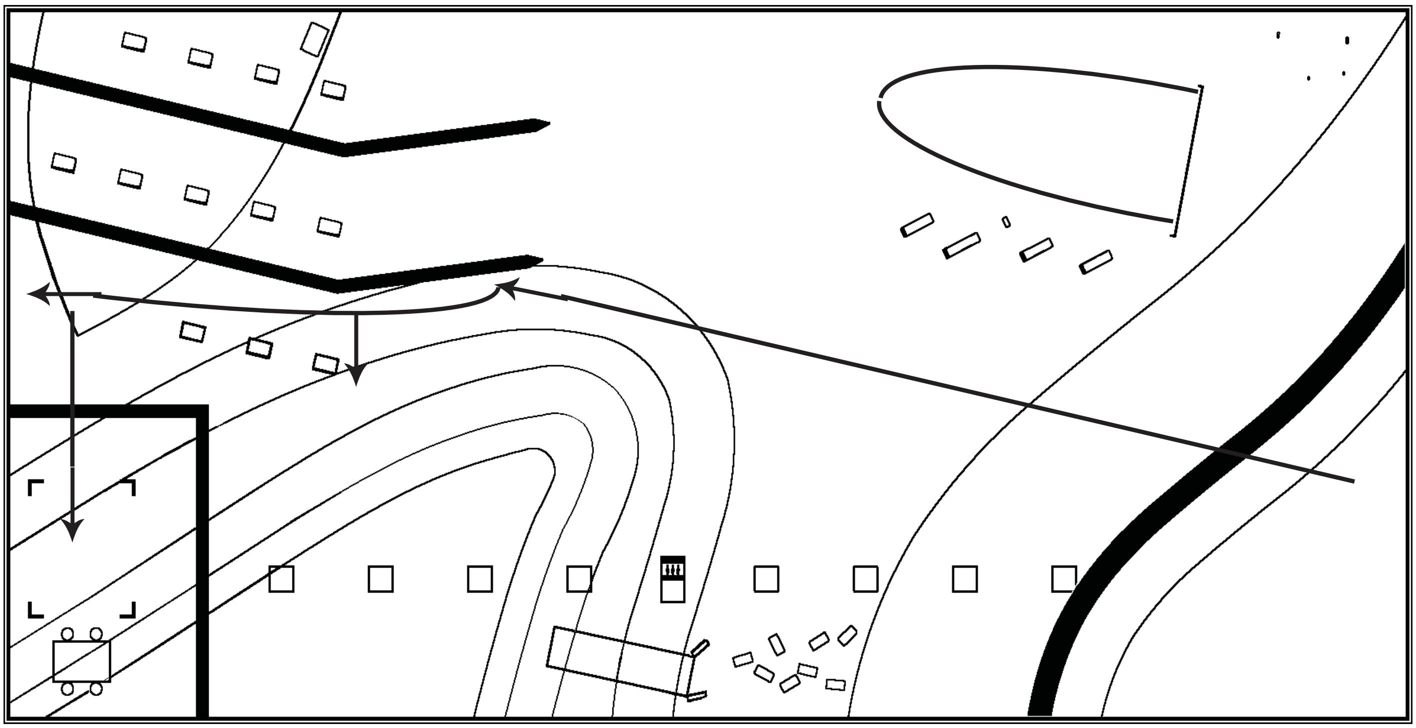
Raise the Rows of Flags and Protect Pump Station Mission

The objectives here were to raise all the flags on each of the 3 rows and to push a protective structure over the pump station. The team was only able to work out a reliable solution for one row of flags. This was the one mission for us that dictated more programming. The original plan was to go straight to the short edge of the table and on the way use flexible axles on the right hand side to brush the flags up. There would be a rolling cart that would trigger a “hammer” perpendicular to the edge of the table and push the protective structure over the pump station. This would make the path simple to program but the hammer was not reliable plus the cart had to navigate over a long distance through a very narrow pass between the flags and the pipeline. The flags portion of the mission worked but the protective structure was unreliable and the narrow path made for a narrow cart which was unstable.



Raise the Rows of Flags and Protect Pump Station Mission

So they changed the path to make use of the black line which then necessitated a line follower program which they were able to progtram using Robolab 2.5.4. It was still a straight line shot from base but at an angle to allow the light sensor to read the lower black line. From then on the robot followed the line till it reached the edge of the table. On the way, it would use the Technic Flexible Axles to brush the flags up on the left hand side. There were 2 flexible axles one in the middle of the robot and one at the back. The front flexible axle would raise the flag while the back flexible axle would keep it up while the front flexible axle raised the next one in the sequence. Some initial missed readings of the black line was overcome by a hooded or shielded light sensor. The shot out of base was made more reliable with a jig to help position the robot. Finally 2 more flexible axles were attached to the very front of the robot as whiskers to increase contact with the protective structure as the robot pushed it over the pump station.



Conclusion

I presented 6 techniques that can be used to generate new ideas especially to affect manipulator design. I recommend using Analysis of Past Solutions, Brainstorming and Brainwriting intially with the entire group to generate ideas for prototypes. Then in smaller groups or individuals use Attribute Listing, Morphological Analysis and Orthogonal Thinking to help refine prototypes and iterate into better solutions.

Reference:

von Oech, R., (1998). *A Whack on the side of the Head.* New York: Time Warner Book Group.

Higgins, J.M. (1998). *101 Creative Problem Solving Techniques*" Florida:Warner Business Books.