FAMU-FSU Engineering

SoutheastCon 2020 Hardware Competition

Virtual Design Review 2

Team Introductions

Isabel Barnola
Lead Software Engineer

David Bowen
Project Manager & Lead Robotics Engineer

Diego Campos
Lead Signal Process Engineer

Alex Ndekeng
Lead Power Electronics Engineer

Abiel Souverain
Lead Design Engineer

Sponsor and Advisor

FAMU-FSU College of Engineering

Engineering Mentor
Jerris Hooker, Ph.D.

Academic Advisor
Bruce A. Harvey, Ph.D.

Objective

The objective of the project is to build an autonomous robot with the capabilities of completing at least one of the two challenges set for the 2020 SoutheastCon hardware competition.

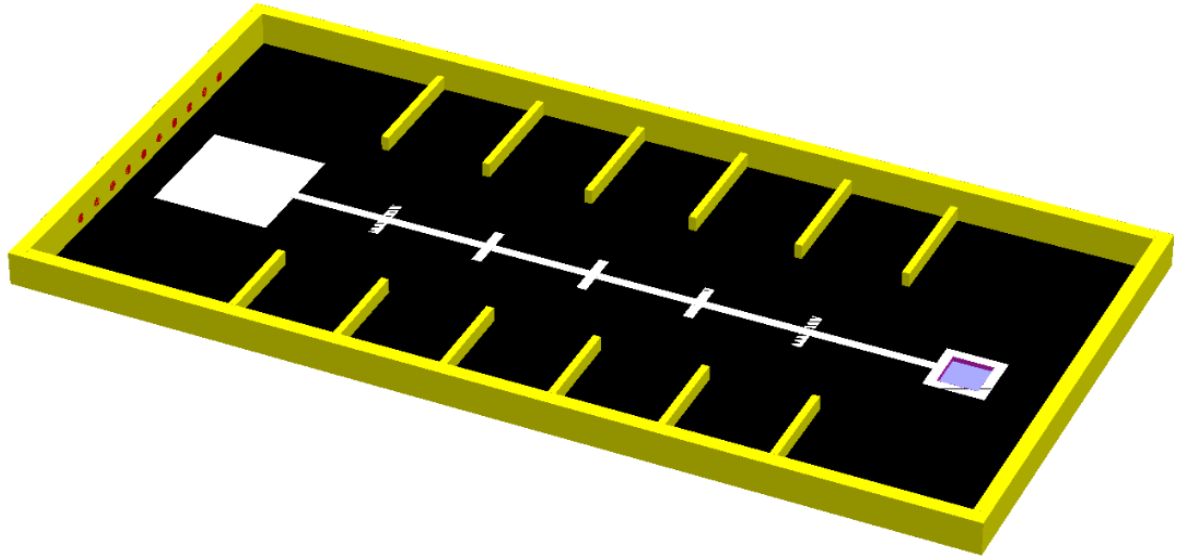
Alex Ndekeng

Project Background

Alex Ndekeng

2020 Southeast Con hardware competition

- 1st challenge: accurately stack Lego
  Duplo blocks representing the digits of pi.
- 2nd Challenge: push buttons in an order that represents the digits of pi



Description	Number of points
Total stack sequenced correctly	20 * N * N
Additional stack not sequenced correctly	N * N
Total button presses sequenced correctly	10 * N
Additional button presses not sequenced correctly	N (max of 100 counted)

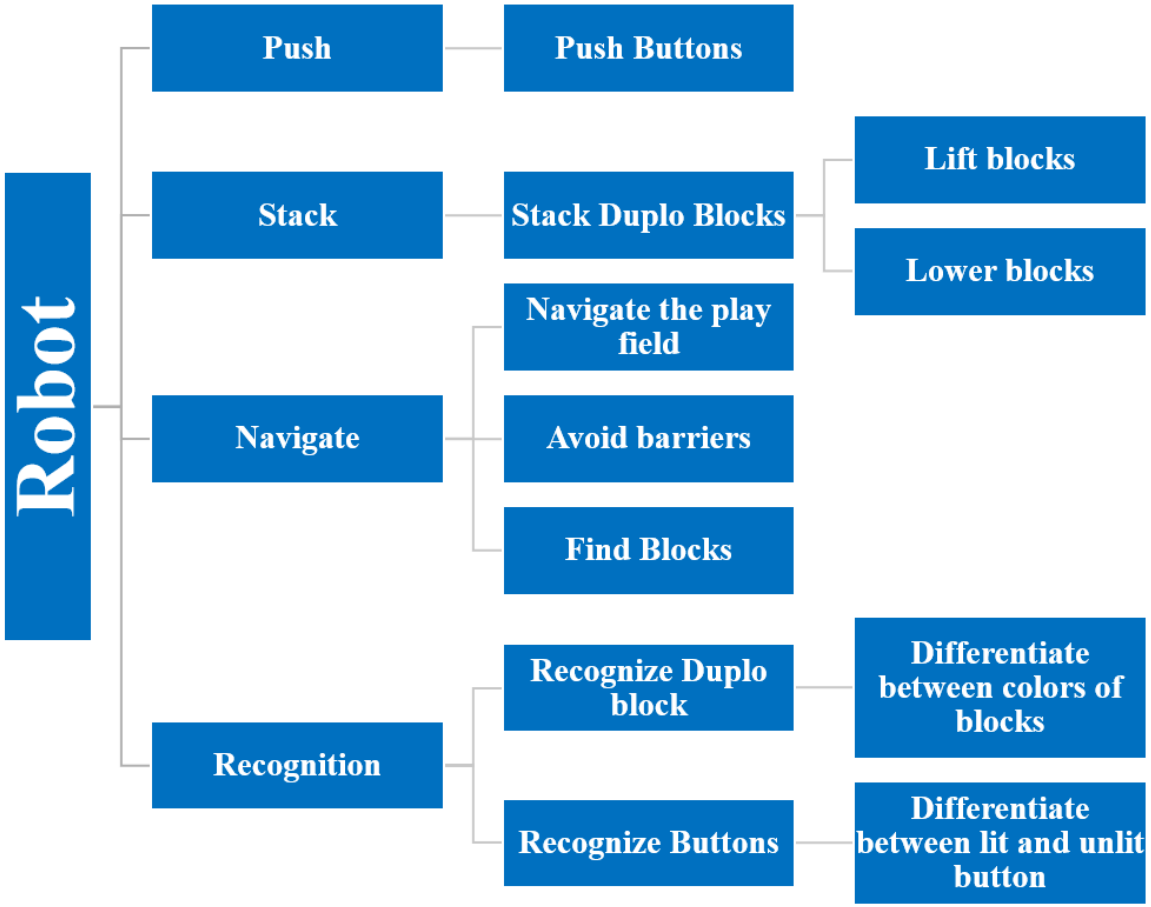
Alex Ndekeng

Customer Needs

- We're having our customers be the same as our primary and secondary markets as well as our stakeholders
- 12"x12"x12" autonomous Robot
- Ability to pick up to pick up Lego blocks and stack them
- Ability to push buttons recessed in a wall
- Ability to stack Legos or push buttons in the order of the numbers of pi
- Navigate through the arena

Alex Ndekeng

Functional Decomposition



Alex Ndekeng

Targets and Metrics

Abiel Souverain & Diego Campos

Targets and Metrics

- Some of the measurements will be taken through sensors
  - Several functions will use the same sensors
- Navigate the play field contains the critical target

Functions	Metrics	Target
Navigate the Play Field*	Number of path combinations completed	10
Avoid Barriers	Distance from barrier (inches)	>1 in
Push Buttons	Depth of button push (inches)	1/8 in
Find Block	Time to locate block (seconds)	<5 sec
Lift Duplo Block	Height reached (inches)	~1.5 block height above previous block
Lower Duplo Block	Height reached (inches)	1 block height above previous block
Differentiate between buttons	Time to locate proper button (seconds)	<10 sec
Differentiate between blocks	Time to reach correct bin (seconds)	<20 sec

* Indicates Critical Targets

Abiel Souverain

Validation

- The mission critical functions include to navigate the playfield, recognize where the Duplo blocks are at, pick the Duplo blocks and stack them correctly at the base.

- Replica arena and blocks for testing.
  - Several tests will be made in order to assess the successfulness of the design.

Validation

- **Navigation:** The robot will need to pass successfully different checks such as navigating correctly to the base, and to each of the bins.
- **Recognition:** The robot will be assigned to go to a bin having Duplo blocks and will need to stop once it encounters blocks at a “pick up” distance.

Abiel Souverain

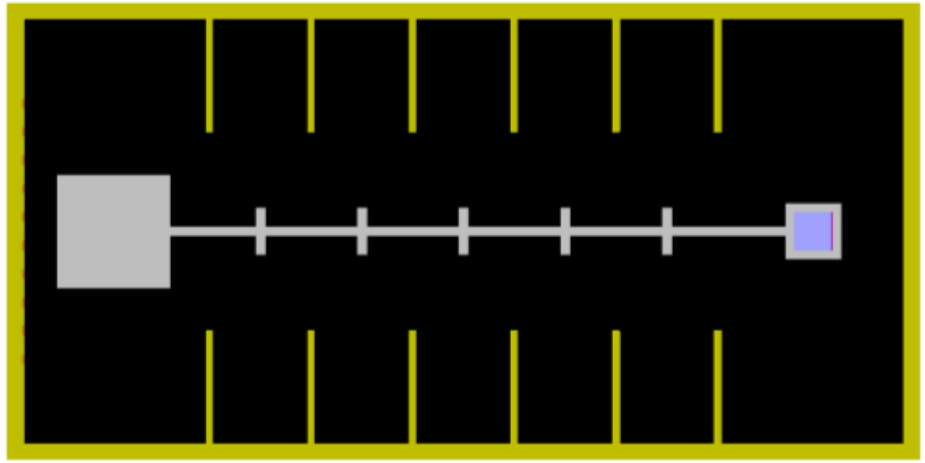
Validation

- **Pick up:** The robot will have several blocks laying at a “pick up” distance and it will need to pick them up successfully, this implies that the robot must pick up the blocks and not let them go unless specified.
- **Stacking:** A set of tests will be made to check that the robot effectively stacks the Duplo Blocks.

Abiel Souverain

Minimum Targets

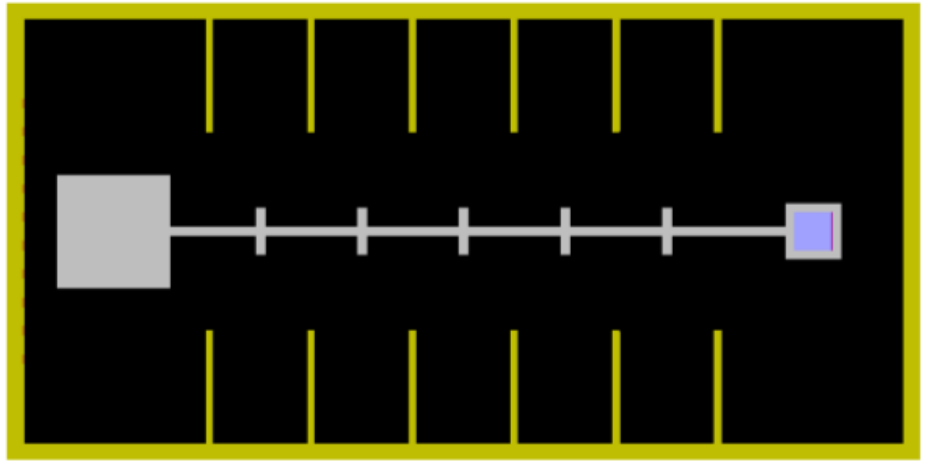
1. 100 points through button pressing.



2. Score at least as many points through stacking as through button pressing.

Maximum Targets

1. 3380 points through correct block stacking (13 blocks)
2. 3600 points through incorrect block stacking (60 blocks)
3. 1500 points through button pressing



Diego Campos

Measurements

- The “navigate the play field” function is broad and may require some additional metrics to fully define it.

- The “avoid barriers” function will probably use the same sensors as the “navigate the play field” function.

Measurements

- Both the “Differentiate between buttons” and the “Differentiate between blocks” functions are measured by the time to reach the appropriate location.
- Lifting and lowering the block will be measured by the height difference between the current block and the previous block placed.

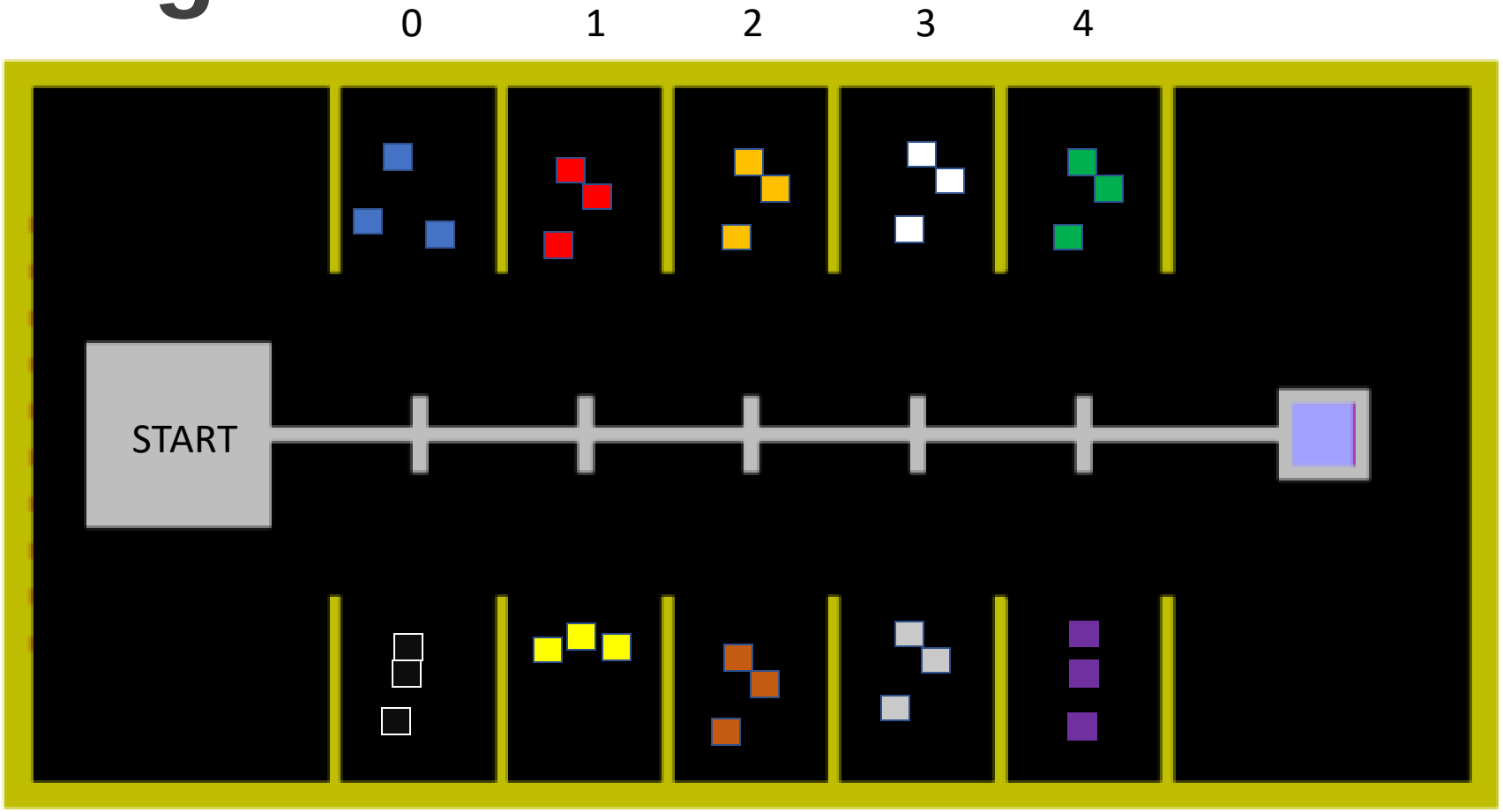
Diego Campos

Concepts

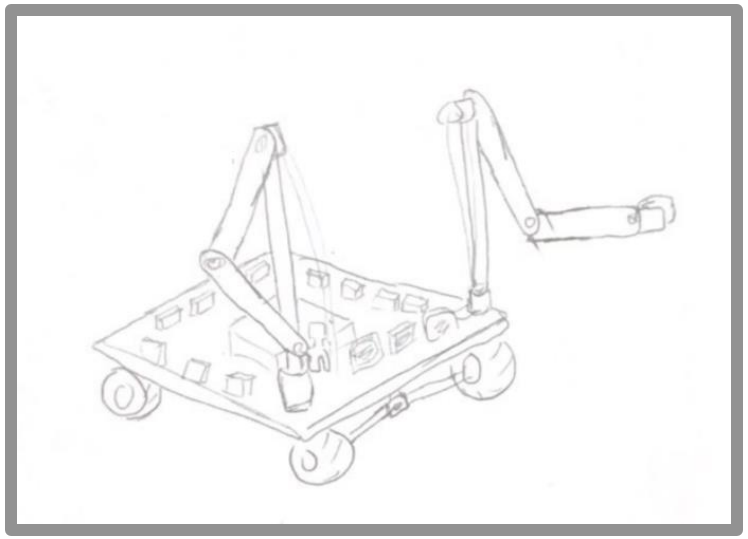
Isabel Barnola

Challenge

180 Seconds

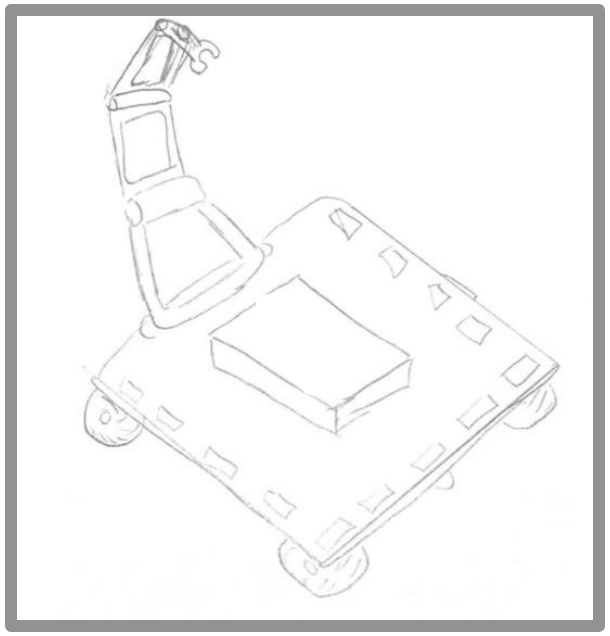


Concepts 1-2



Robot with two arms

- 2 arms to hold the Lego and stack it and has a
- Hammerlike appendage on top of one arm.

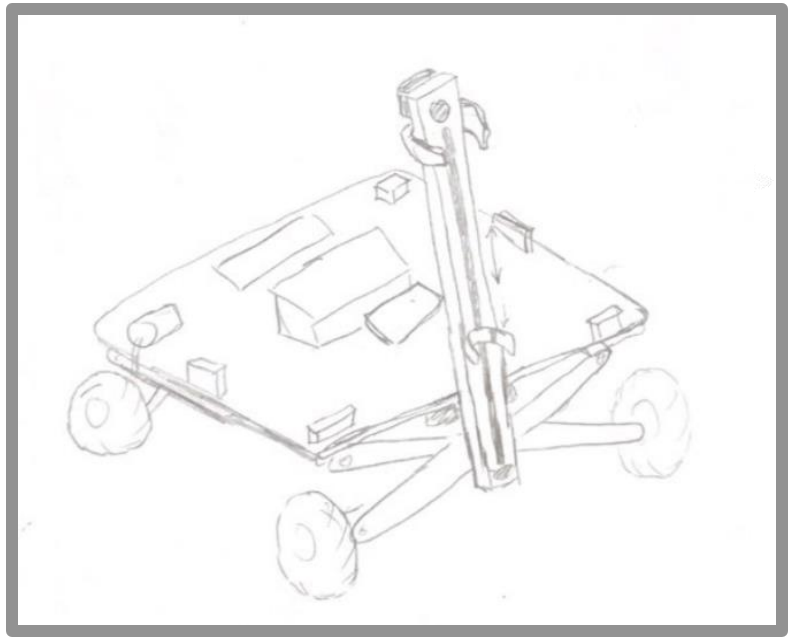


Scorpion

- 4 motors in the “tail.”
- Individual motors in wheels

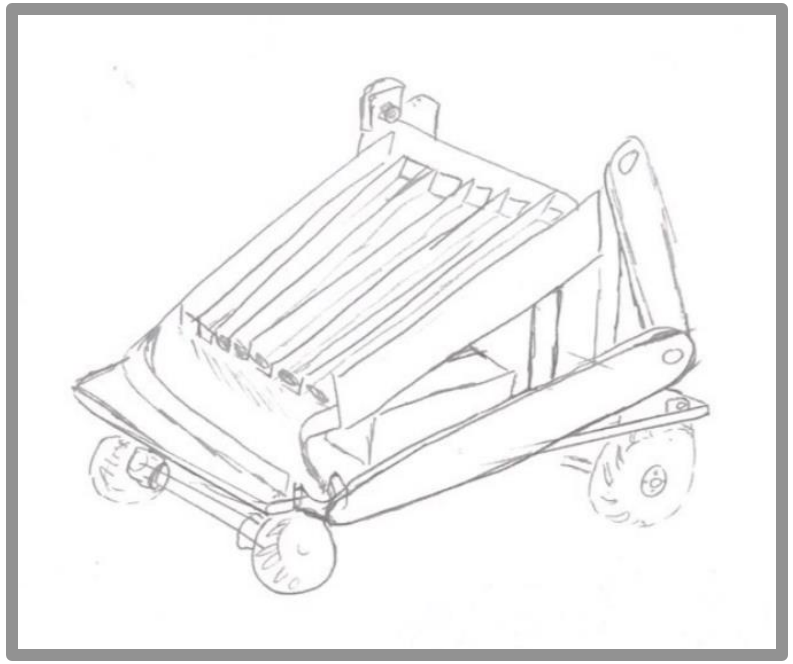
Isabel Barnola

Concepts 3-4



Robot with 2 claws and lift kit.

- Two claws to raise and lower blocks.
- It will find blocks using sonar.
- Lift kit.

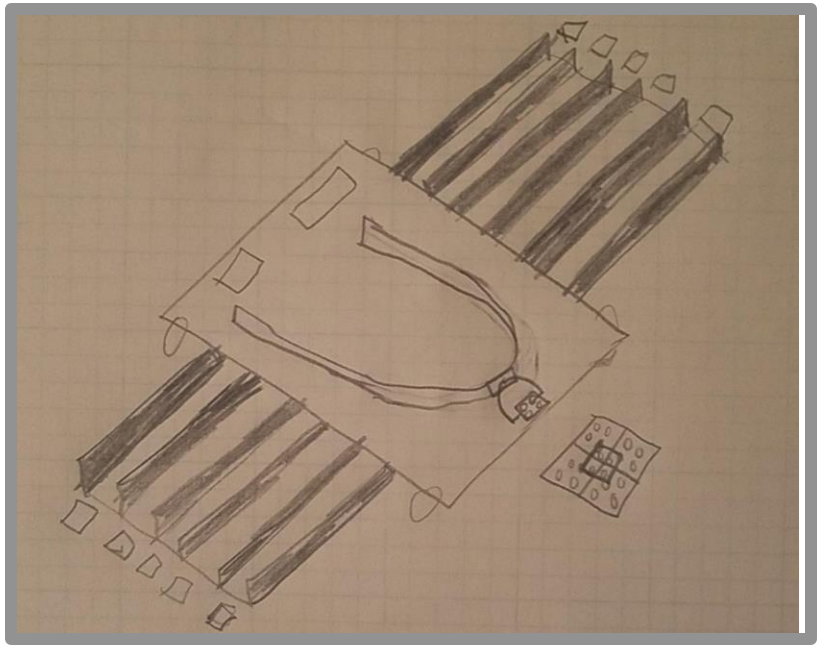


Color Sorting Robot

- Sorter on its body with blocks that slide in.
- Elevator and claw
- 3 DoF arm

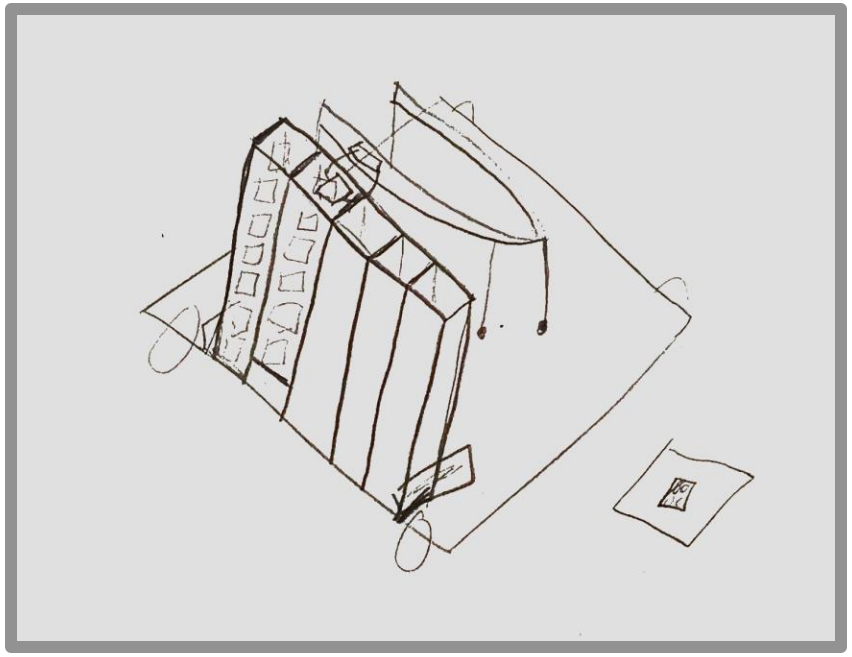
Isabel Barnola

Concepts 5-6



Slide System

- Slide system on either side to collect the blocks.
- Claw on a track to move grab the next block in the sequence and stack it.

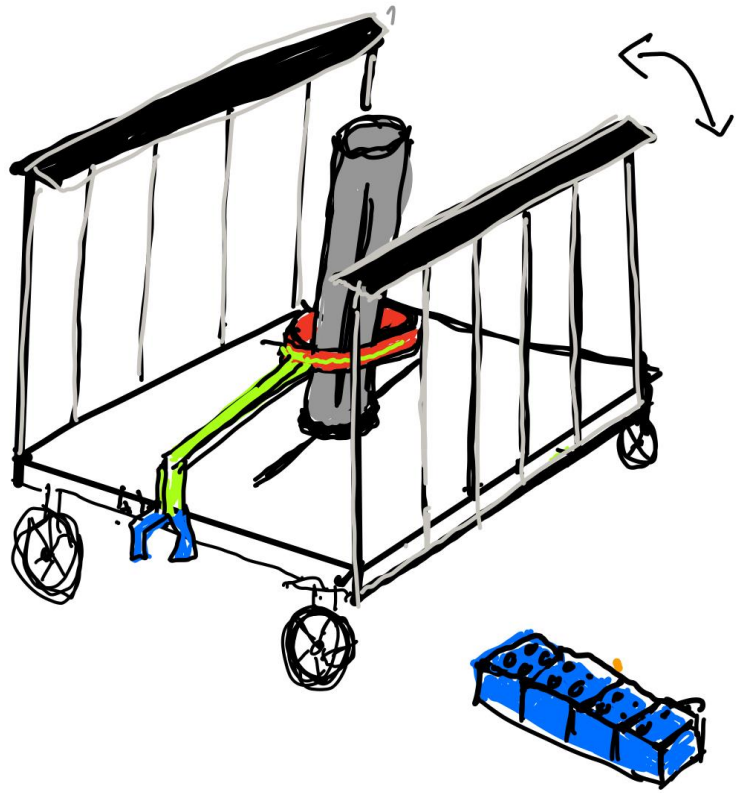


Spring Elevator

- spring-based elevator in 10 individual hoppers to store and supply bricks.
- It will have a claw track for stacking.

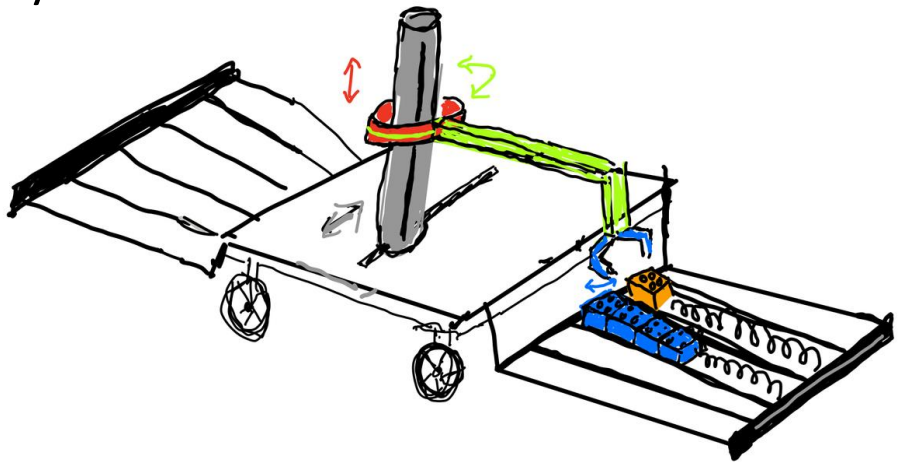
Isabel Barnola

Concept 7



Stingray

- Net-like arms.
- Arms used to drag the Legos from the bins in an organized fashion to the base.
- From there an arm, composed of a lift and a claw that moves 360 degrees pick up the Lego blocks and stack them correctly on the base.



Isabel Barnola

Concept Selection

David Bowen

Analytical Hierarchy Process

Concept	Alternative Value
Datum - Color Sorting	0.113
Scorpion	0.133
Robot with two arms	0.152
Claws and lift kit	0.185
Slide system	0.098
Spring-based elevator	0.100
Stingray	0.219

David Bowen

House of Quality

Engineering Characteristics								
Units		ft/s^2	in	in	s	s	s,in	s
Customer Requirements	Importance Weight Factor	Acceleration	Distance from Barrier	Block height (raising and lowering)	Time to Reach Correct Bin (Color Determination)	Design/Build Time	End Time behavior	Time to locate block within bin
Stack Duplo Blocks Correctly	6	1	5	9	9	9	1	5
Mobility	5	5	9	5	5	9	9	5
Robot Volume	7	1	5	5	1	1	1	5
Color Recognition	3	5	1	5	5	5	1	1
Speed	4	9	1	1	9	9	9	5
Automatic Shutdown	2	5	1	1	1	1	9	1
East of Implementation	0	5	5	9	5	9	1	5
Button Pushing	1	1	1	1	1	5	1	1
Raw Score		97	81	89	85	109	101	69
Relative Weight %		18%	15%	16%	15%	20%	18%	13%
Rank Order		3	6	4	5	1	2	7

David Bowen

Pugh Matrix

	Datum	Concepts					
Engineering Characteristics		Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Acceleration		+	+	+	+	S	+
Distance from Barrier		+	+	+	S	S	S
Block height (raising and lowering)		S	+	S	S	S	+
Time to Reach Correct Bin (Color Determination)		-	-	S	+	-	+
End Time behavior		+	+	+	+	S	S
Design/Build Time		S	-	+	+	-	S
Time to locate block within bin		S	-	S	+	S	+
Sum of Pluses		3	4	4	5	0	4
Sum of Minuses		1	3	0	0	2	0
Rank		4	3	2	1	5	2

	Datum	Concepts		
Engineering Characteristics	Scorpion	Stingray	Slide system	Claws and lift kit
Acceleration		S	-	-
Distance from Barrier		-	-	S
Block height (raising and lowering)		+	S	+
Time to Reach Correct Bin (Color Determination)		+	+	+
End Time behavior		-	+	S
Design/Build Time		S	S	+
Time to locate block within bin		+	+	+
Sum of Pluses		3	3	4
Sum of Minuses		2	2	1
Rank		2	2	1

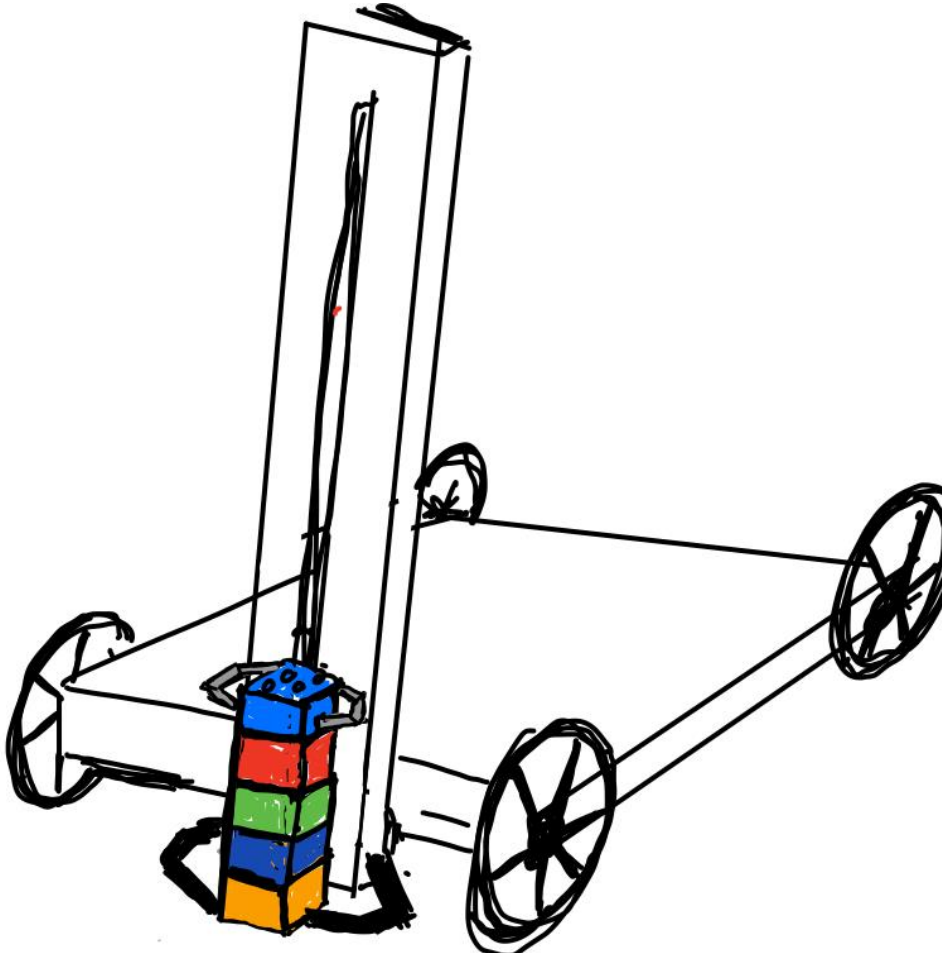
David Bowen

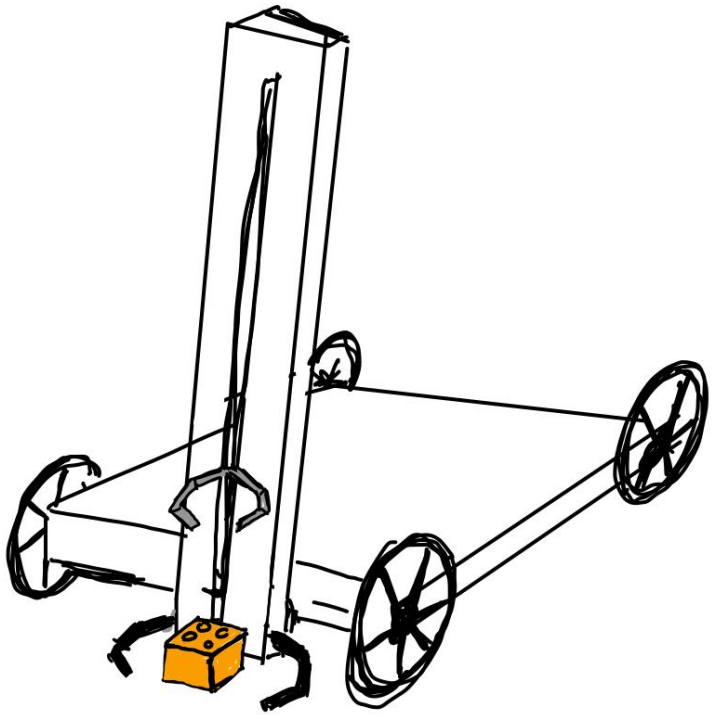
Analytical Hierarchy Process

Concept	Alternative Value
Datum - Color Sorting	0.113
Scorpion	0.153
Robot with two arms	0.139
Claws and lift kit	0.190
Slide system	0.095
Spring-based elevator	0.095
Stingray	0.179

David Bowen

Claws and Lift Kit





David Bowen

Future Work

- The design may still need to be revised
- Parts must be sourced and purchased/designed
- Software Framework – C++
- 3D CAD Design – Creo Parametric

David Bowen

End of semester goal

- Risk Assesment
- Spring Plan
- VDR3/Poster Session
- Line following prototype

David Bowen

4 Most Important Points

1. The critical target to meet was that of navigating the play field.
2. The final concept chosen was the Stingray design.
3. The final design may still be revised.
4. The software design and 3D CAD design have been started.

David Bowen

Thank you for your time.

Team Email: southeastcon@admin.my.fsu.edu

Review | Final Design | Concepts | Targets & Metrics | Future Work

Detailed AHP | Pugh Matrix

David Bowen

Backup Slides

Concept Selection Backup

Pugh Matrix

Engineering Characteristics	Datum	Weights	Scorpion	Robot w/ two arms	Claws and lift kit	Slide System	Spring based elevator	Stingray
Acceleration	0	1	1	1	1	1	0	-1
Distance from Barrier	0	1	1	1	1	0	0	1
Block Height	0	2	0	1	0	0	0	1
Time to reach correct bin	0	1	-1	-1	0	1	-1	0
End time behavior	0	1	1	1	1	1	0	1
Time to locate block within bin	0	1	0	-1	0	1	0	1
Total Score	-	-	2	3	3	4	-1	4
Rank	-	-	5	3	3	1	6	1

Pugh Matrix

Engineering Characteristics	Weights	Datum(Scorpion)	Robot with two arms	Slide System	Claws and lift kit	Stingray
Acceleration	1	0	-1	-1	-1	-1
Distance from barrier	1	0	0	-1	0	0
Block height	2	0	1	0	1	1
Time to reach correct bin	1	0	0	1	1	1
End time behavior	1	0	0	1	0	1
Time to locate blocks within bin	1	0	1	1	1	1
Total	-	-	1	1	3	4
Rank	-	-	3	3	2	1

Criteria Weights

	Acceleration	Distance from Barrier	Block height (raising and lowering)	Time to Reach Correct Bin (Color Determination)	End Time behavior	Time to locate block within bin
Acceleration	1.000	5.000	0.333	1.000	3.000	0.333
Distance from Barrier	0.200	1.000	0.333	0.333	1.000	0.200
Block height (raising and lowering)	3.000	3.000	1.000	1.000	1.000	0.333
Time to Reach Correct Bin (Color Determination)	1.000	3.000	1.000	1.000	5.000	1.000
End Time behavior	0.333	1.000	1.000	0.200	1.000	0.143
Time to locate block within bin	3.000	5.000	3.000	1.000	7.000	1.000
Sum	8.533	18.000	6.667	4.533	18.000	3.010

Criteria Weights

Criteria	Criteria Weights
Acceleration	0.157
Distance from Barrier	0.054
Block height (raising and lowering)	0.176
Time to Reach Correct Bin (Color Determination)	0.211
End Time behavior	0.065
Time to locate block within bin	0.337

Acceleration Ratings

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	0.200	0.333	0.200	1.000	0.333	1.000
Scorpion	5.000	1.000	1.000	3.000	5.000	5.000	3.000
Robot with two arms	3.000	1.000	1.000	0.200	5.000	1.000	3.000
Claws and lift kit	5.000	0.333	5.000	1.000	5.000	3.000	3.000
Slide system	1.000	0.200	0.200	0.200	1.000	0.333	3.000
Spring-based elevator	3.000	0.200	1.000	0.333	3.000	1.000	3.000
Stingray	1.000	0.333	0.333	0.333	0.333	0.333	1.000
Sum	19.000	3.267	8.867	5.267	20.333	11.000	17.000

Distance From Barrier Ratings

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	0.333	0.333	0.333	3.000	1.000	1.000
Scorpion	3.000	1.000	3.000	1.000	5.000	3.000	3.000
Robot with two arms	3.000	0.333	1.000	1.000	3.000	1.000	1.000
Claws and lift kit	3.000	1.000	1.000	1.000	5.000	3.000	1.000
Slide system	0.333	0.200	0.333	0.200	1.000	0.333	0.333
Spring-based elevator	1.000	0.333	1.000	0.333	3.000	1.000	1.000
Stingray	1.000	0.333	1.000	1.000	3.000	1.000	1.000
Sum	12.333	3.533	7.667	4.867	23.000	10.333	8.333

Block Height Capabilities (Raising and Lowering)

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	1.000	1.000	0.333	3.000	0.333	3.000
Scorpion	1.000	1.000	1.000	0.333	3.000	1.000	1.000
Robot with two arms	1.000	1.000	1.000	0.200	1.000	1.000	0.333
Claws and lift kit	3.000	3.000	5.000	1.000	3.000	3.000	1.000
Slide system	0.333	0.333	1.000	0.333	1.000	0.333	0.333
Spring-based elevator	3.000	1.000	1.000	0.333	3.000	1.000	1.000
Stingray	0.333	1.000	3.000	1.000	3.000	1.000	1.000
Sum	9.667	8.333	13.000	3.533	17.000	7.667	7.667

Color Determination

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	3.000	5.000	1.000	5.000	3.000	1.000
Scorpion	0.333	1.000	1.000	0.200	0.333	1.000	0.333
Robot with two arms	0.200	1.000	1.000	0.333	0.333	0.333	0.200
Claws and lift kit	1.000	5.000	3.000	1.000	3.000	3.000	0.333
Slide system	0.200	3.000	3.000	0.333	1.000	1.000	1.000
Spring-based elevator	0.333	1.000	3.000	0.333	1.000	1.000	1.000
Stingray	1.000	3.000	5.000	3.000	1.000	1.000	1.000
Sum	4.067	17.000	21.000	6.200	11.667	10.333	4.867

End Time Behavior

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	0.333	0.333	1.000	1.000	3.000	1.000
Scorpion	3.000	1.000	1.000	1.000	0.333	5.000	3.000
Robot with two arms	3.000	1.000	1.000	3.000	1.000	5.000	1.000
Claws and lift kit	1.000	1.000	0.333	1.000	1.000	5.000	0.333
Slide system	1.000	3.000	1.000	1.000	1.000	3.000	1.000
Spring-based elevator	0.333	0.200	0.200	0.200	0.333	1.000	0.333
Stingray	1.000	0.333	1.000	3.000	1.000	3.000	1.000
Sum	10.333	6.867	4.867	10.200	5.667	25.000	7.667

Time to Locate Block in Bin

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	1.000	0.200	1.000	0.333	1.000	0.333
Scorpion	1.000	1.000	0.333	1.000	0.333	1.000	0.333
Robot with two arms	5.000	3.000	1.000	5.000	3.000	3.000	0.200
Claws and lift kit	1.000	1.000	0.200	1.000	1.000	1.000	0.250
Slide system	3.000	3.000	0.333	1.000	1.000	1.000	0.250
Spring-based elevator	1.000	1.000	0.333	1.000	1.000	1.000	0.250
Stingray	3.000	3.000	5.000	4.000	4.000	4.000	1.000
Sum	15.000	13.000	7.400	14.000	10.667	12.000	2.617

Final AHP Matrix

Final Matrix Transposed						
	Acceleration	Distance from Barrier	Block height (raising and lowering)	Time to Reach Correct Bin (Color Determination)	End Time behavior	Time to locate block within bin
Datum - Color Sorting	0.047	0.091	0.102	0.249	0.106	0.069
Scorpion	0.304	0.284	0.117	0.059	0.199	0.072
Robot with two arms	0.161	0.146	0.091	0.044	0.206	0.238
Claws and lift kit	0.259	0.213	0.318	0.209	0.118	0.074
Slide system	0.061	0.041	0.058	0.116	0.181	0.117
Spring-based elevator	0.116	0.103	0.151	0.104	0.038	0.076
Stingray	0.052	0.123	0.163	0.219	0.153	0.355