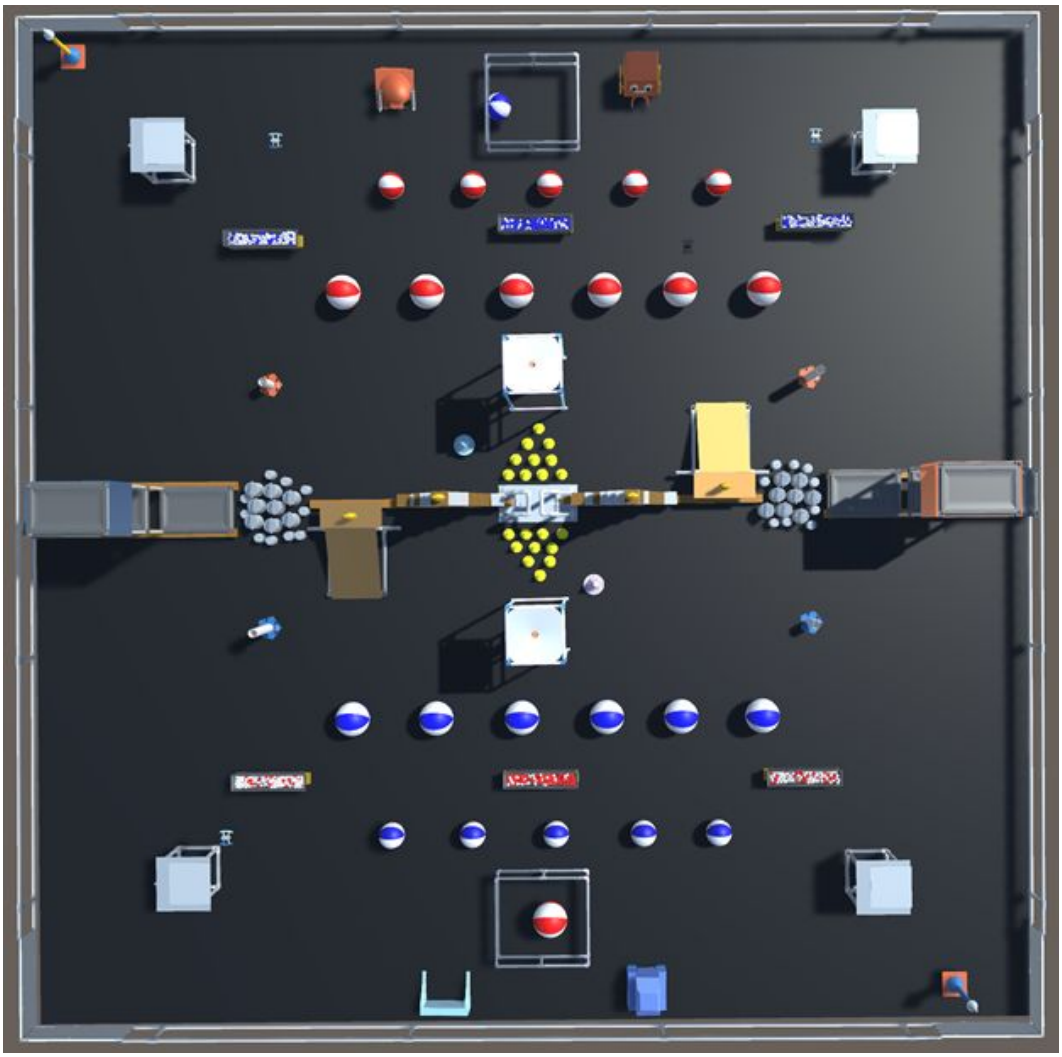
RDL

ROBOT DRONE LEAGUE



2018 MineField

Three Laws of Robotics *and I*

1. *A robot may not injure a human being or, through inaction, allow a human being to come to harm.*

2. *A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.*

3. *A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.*

~Isaac Asimov

4. ***A robot may not intentionally injure another robot unless the action or inaction conflicts with the First, Second or Third Laws. ~TechGarage***

Contents

Robot Drone League

Introduction

MineField is being introduced in 2017 with enhancements in 2018 as a new and more engaging competitive robotics program for elementary, middle and high school students. The purpose of the game is to help the next generation of students find their passion in the fields of engineering at a young enough age where school has a purpose. The smartphone generation is unlike any prior generational defined group of students and they are looking for complex challenges to stimulate their minds. When we hand a smartphone to a 5-year-old we are giving them access to a world of information and a never-ending stream of complex challenges in video games. This has re-trained their brain to learn quickly with no supervision and to embrace the concept of “failing early and failing often” in order to reach the next level.

What hasn’t changed is the level of expectations of achievement and accomplishment in our school system where the standard is the traditional methods of lecture-based teaching and submitting a worksheet. We need students to learn skills related to critical thinking, problem-solving, communication, collaboration, creativity, and innovation. Project or challenge-based learning unlocks the potential of every student without the constraints of grade level or ability by leveraging the desire to solve a problem or compete against fellow students. It is amazing to see what can be accomplished when you challenge the smartphone generation with a problem then get out of their way and allow them to solve the problem.

The Robot Drone League represents the ultimate challenge for the next generation of students who want to show what they can accomplish - without any help from parents, teachers or mentors. The field is large, the game is longer, the robots are bigger, the drones are ready for action and the on-field challenges worthy of their time and effort.

League Overview

The Robot Drone League season will run from early September through mid-December and will be a multi-year game where a percentage of scoring elements are changed each year and point values adjusted. Teams will consist of eight members that are required to build two robots and program two drones. The intent is to have two team members per robot and per drone to maximize the hands-on responsibility and the learning that goes with it. The group will need to work together as a team but also have individual responsibility. Having one team member build and design two robots and one team member program both drones is not in the spirit of the Robot Drone League. This contrasts with other programs that can have ten members on a team where the robot simply isn’t big enough or complex enough to have all team members fully engaged. This is further challenged by teams that have very involved mentors or teachers that

like to build robots and enjoy winning. Teams should benefit from the guidance of teachers or mentors with the constraint that only the students should touch the robot or write code for the drone. If the mentor or the teacher can convince or guide the students towards a particular strategy or mechanical system that type of engagement is encouraged. It is our experience that the students have no interest in guidance related to design or building. However, when faced with a challenging problem, students appreciate guidance on different ways the problem can be solved or ways to improve upon an existing student-driven design. In the interest of fairness to other teams in the context of the All-star award teams will be asked to declare any contribution to the design and building of the robot by a mentor.

The Robot Drone League is making programming just as important as building robots and has standardized on the Bebop drone platform by Parrot as well as the Unity gaming platform. The Parrot platform is the only drone that has a full-featured API to fly a drone. Other platforms offer an API to stream video, data or issue GPS waypoints for outdoor flight but do not allow remote indoor flight control. For the last two years, the Robot Drone League has been testing a Python-based API with full camera/OpenCV integration and are excited about the learning potential of programming drones in autonomous mode as well as the excitement of drones under operator control in a match. Drones will also have a mechanical build component to add and control attachments which will need to be lightweight and functional. Programmers will work with CAD models of their robots (developed by the team), and load it into the Unity game engine for an online multi-player version of the game. In 2018, Magic Leap Augmented Reality will be added into the game and we are excited about this high-tech twist. Additionally, in 2018, TechGarage will be introducing a Raspberry PI based control system designed by TechGarage alumni Kirill Safin as the recommended control system. Teams can use any control system and we welcome innovation and teams challenging themselves to be different.

Team Organization

Teams based on age and skill level will be organized into a division of 4-5 teams when possible. A team will consist of eight students, two robots, and two drones and will compete as a group against other teams in the league. Teams will be scheduled to compete against another team in two matches at a tournament where each match lasts 10 minutes and will take approximately an hour.

Differential Scoring

The Robot Drone League will use differential scoring similar to a golf handicap to reward teams that improve during the season and thereby giving them a better chance at winning. If Team A has an average match score of 450 points and is competing against Team B which has an average match score of 300 points than Team B will start a match against Team A with 450-300=150 points as their differential score. At the end of the match, Team B scored 325 points which is slightly better than their average and Team A scored 480 points then Team A would win the match as their score of 480 is greater than 325 + 150 = 475 points. The team's

average score will be based on points scored in matches and does not include bonus or handicap points. The Robot Drone League reserves the rights to adjust the rules of differential scoring if scenarios exist that give a team a winning strategy of trying to purposely keep their match average as low as possible. This allows teams to focus on incremental improvement of the robot during the season as opposed to designing and building a robot that does everything at the first tournament and rarely does anything because the robot hasn't been tested.

Team Ranking Tournaments

The win-loss record during the regular season will be used to rank teams in their division for the end of the season tournament. In the event of a tie, the team with the higher average match score will be ranked higher and if needed by the highest match score and finally the best two out of three of rock paper scissors. In the end-of-the-season tournament, the seeding will be used in each division for 1 to play 4 and 2 to play 3, etc. If there are an odd number of teams in a division; then the two lowest ranked teams will play each other as a play-in-game. The tournament will be a double elimination tournament and use differential scoring. Teams that lose a match will drop into a loser bracket where the next loss in the loser bracket will be eliminated from the tournament. Tournament brackets will be established to have teams of similar age and experience compete against each other with the ultimate goal of the best team from the lower divisions could compete against the best team from the higher division using differential scoring.

All-Star Team

Many elements contribute to winning a tournament and luck is probably the one element that consistently makes a major impact and is outside of our control. A good team that is lucky will do well. The All-Star team for each division will recognize the best robots and drones from the league where each team member will vote for the top four robots and top four drones. Team members will not vote for a robot or drone on their team. The two robots and two drones with the highest vote totals will be selected as the All-Star team and represent the highest achievement in the Robot Drone League as it is based on recognition by peers. Teachers, Parents or Mentors should not try and influence the vote of any team members. However, team members should make a serious effort in the selection of a robot or drone that they wish they had on their team. Teams will be asked to declare all contributions to the robot by a mentor and that should be considered when team members vote for robots and drones that they feel are deserving of being selected on the All-Star team.

Skills Certification

As the goal of the Robot Drone League is to create learning opportunities in the field of engineering, individual participants will be able to earn various levels of skill certifications in CAD, Java, Python, OpenCV, Unity, Autonomous, Simulation, Mechanical, and Sensors. Each area will have skill certification levels of beginner, intermediate, advanced, master and instructor. For beginner certification, the expectation is that the participant will be able to demonstrate independent knowledge of a skill. For intermediate certification, a participant will

have to complete tutorials, outlined by the Robot Drone League, designed to give broad exposure to a skill. For advanced certification, a participant will present an independent project, as a YouTube video, that is a critical element of their robot or drone for review by mentors. For master skill certification, the participant will develop an independent project as a YouTube video showcasing their knowledge. For instructor certification, a participant must have a master certification for one year and work as an instructor for that specific skill as part of a summer camp program. At least 50% of the participants in the camp program led by the instructor will need to reach intermediate certification in order for the instructor to earn the instructor certification. The Robot Drone League will recognize each skill certification on its website when the various levels are achieved. The site will also contain references to a short description of the advanced and master level projects with links to the videos. Participants are encouraged to reference these certifications when applying for college admissions, scholarships, internships and work in the field of engineering.

National Engineering Skills Challenge

The Robot Drone League will work towards hosting a National Engineering Skills Challenge in mid-August. This competition is designed to recognize the mastery of specific engineering skills. This will be a national championship event where participants will compete for specific skill challenges. Participants will compete for bronze, silver, gold, platinum and diamond designation in a specific skill challenge. The competition will also provide an overall ranking in each specific skill challenge. Participants will be able to compete in multiple skill challenges which can be used to rank overall engineering skills.

Robot Drone Specifications

The game has numerous scoring strategies which will impact the design and construction of the team robots and the programming of the drones. Following the Four Laws of Robotics; safety will be the primary concern for humans, robots, and drones related to inspection. If a robot or drone is not deemed safe it will not be allowed to compete.

Robot

The starting configuration of the robot will not exceed 624 mm x 624 mm x 624 mm. The robot can use any control system - it is highly recommended that systems available for TechGarage, FRC, FTC or VEX be strongly considered. A robot must use a single battery approved for FTC or VEX with an easily accessible on/off switch and battery rated fuse. A robot will be allowed one battery change during a 10-minute match. A robot that has a mechanical or electrical failure can be rescued by a field service technician.

Robots cannot use hydraulics but pneumatics are allowed with supply side air pressure limited to 60 psi. Any team wanting to use pneumatics must contact the league for prior approval.

Drone

The Robot Drone League has standardized the Bebop drone platform sold by Parrot (http://www.parrot.com). It is a low cost and highly functional drone platform with an open API for remote flight that is not available in any other drone platform. The Bebop or Bebop 2 drone can be used in the Robot Drone League and teams can use the programming toolkits available from Parrot or the Python/OpenCV platform provided by the Robot Drone League. For teams that do not have highly skilled programmers, it is recommended that the Python/OpenCV be used. The Robot Drone League will provide a USB Ubuntu boot drive with Python/OpenCV and the drone API already installed/configured.

The Robot Drone League has tested using Bluetooth to remotely control little-bits as well as Arduino feather as an option to have program control of servos and motors attached to the drone. As part of the challenge to score points a team can design a mechanical or a micro-controller based mechanical solution that can be attached to the drone and use the drone battery or external battery. The drones have limited lift capacity which will impact flight time. A drone will be allowed one battery change during a 10-minute match. A drone that has a mechanical or electrical failure can be rescued by a field service technician who will unplug the battery prior to returning the drone to the team. This is for the safety of those handling the drones where it can be a challenge to keep track of which drone is controlled by a team.

Any team wanting to use another drone platform must contact the league for prior approval.

Team Match Participation

Eight Team Members

Each team will consist of eight team members who will be allowed in the pit area at their end of the field. It is anticipated that teams will have other members supporting the team and therefore have more than these eight members affiliated with their team. During a match, a team cannot use other participants outside of the pit area to guide robots or drones. If the team is viewed as using external participants to gain an advantage a yellow or red card (See section on penalties) can be issued. Team members are not allowed on the field during a match and must remain behind the net at all times. Under no circumstances can a team member reach past the net and onto the field. If a robot or drone are not working the field service tech will place the robot or drone outside the net for the team to work on. Teams will be provided a remote gripper to interact with the robot or drone that is stationary on the field adjacent to the area designated for the robot and drone access to the field. Team members who violate the field access rules will be awarded a yellow card as well as the robot or drone that was attempted to be controlled.

Match Setup

A team will be allowed four laptops in the pit area. These laptops can be placed on two eight-foot tables. Teams should make sure the laptops are fully charged and cannot depend on power in the pits. Teams can make use of an unlimited number of smartphones in the pit area. The four teams competing in the same one hour block will be assigned two tables for the duration of their matches. At the end of the match when the head referee has indicated teams should remove their robots and drones from the fields they should be placed on the assigned match tables for repairs and preparation for the next match. Teams should not leave their pit area to work on robot or drones.

Match Scoring

Each team will have a designated Scoring Captain who, at the conclusion of the match, will work with the opposing team's Scoring Captain to complete the scoring worksheet. This will be a complicated game to score and will be limited to a maximum of 5 minutes before the field is reset. A Scoring Captain working with the other team Scoring Captain will capture a picture of each scored element with the opposing team Scoring Captain or assistant in the photo. Scoring Captains will need to work together to quickly record scores for different scoring elements using the captured pictures and the worksheet provided by the Robot Drone League. Scoring captains will work together to tabulate each team's score. The Scoring Captains will each sign the worksheet before submission to indicate that they both agree with the calculated score which will be presented as the final score. Teams that cannot agree on a particular element that needs to be scored can seek the guidance of a league official by showing a video during the match or a post-match photo of the scoring element. Field resets will not be delayed by a disagreement over a scored element.

Field Reset

At the conclusion of each match, after the all-clear from the head referee, robots and drones should be removed from the field as quickly as possible. It is anticipated that the position of a robot or drone may impact a score and the scoring captains should resolve those scoring elements first to expedite removal of the robot or drone. Each team will have a Field Captain and two assistants who, at the direction of the head referee, will be responsible for resetting the field for the next match. The field reset will be done in parallel with the scoring of the game by the Scoring Captains whereas a Field Captain can only reset scoring elements scored by their team. Under no circumstances should a team member reset an element scored by the opposing team.

Penalties

Definitions

1. Following the intent of the Four Laws of Robotics, a robot may not purposely harm another robot unless of course that somehow violates the First law related to the safety of a human. The field is large and it is expected that robots from each team will come in close proximity to each other. Robots will not intentionally contact another robot to play defense or prevent the other robot from accomplishing a task.

2. Purposely blocking a robot with another robot to prevent scoring or movement of the robot will result in a yellow card for the offending robot.

3. Drones are allowed to play defense by popping a balloon on an opposing team's robot. Drones that intentionally crash into a robot as a way to prevent scoring will result in a red card for the offending drone. Drones that crash into an opposing robot are not eligible to be rescued during the match.

4. It is anticipated that a drone will crash into an opposing team drone either through an intentional act or because the drones were simply too close to each other. Drones have a home side that allows them to play defense and score points. If a drone collision occurs; the visiting team will be awarded an automatic yellow card for the drones. If in the opinion of the referee the drone intentionally crashed into another drone or did not show clear intent to avoid a collision a red card can be issued for the drones.

5. If a yellow card is issued for a drone that will apply to both drones where the next yellow card issued for a drone penalty will result in a red card penalty for that drone.

6. If a team is issued a yellow card or red card in the final match of the day that penalty will carry over to the next scheduled match.

Yellow Card

A robot that is issued a yellow card for a penalty will serve as a warning for robot behavior that is not in the spirit of the Robot Drone League. Any yellow card that is issued will be reviewed by league officials at the end of the match to determine if the actions of the robot under the control of the driver were intentional to gain an advantage and a disregard the rules. If the league officials determine that the rule violation was intentional it can become a red card. A yellow card will remain in effect for two matches where a second yellow card will automatically become a red card.

Red Card

A red card issued for a specific robot will result in that robot and designated driver not participating in the next match. The robot or driver will not be allowed in the pit area during the next match. A drone that is awarded a red card will require that a drone and the pilot of the drone to sit out one match. For each red card awarded to a specific robot driver or drone pilot will increase by one match the penalty that the robot or drone will not be able to participate. The robot and driver, as well as the drone and pilot, will carry the accumulation of red card penalties. The goal is to avoid changing drivers or pilots as a way of avoiding additional match penalties. As an example, if a red card is issued to a robot with a prior red card or a driver with a prior red card driving a different robot that will result in a second red card for both the driver and the robot resulting in both sitting out the next two matches.

Video Replay

If video captured by a specific team clearly shows that a yellow or red card should not have been issued a team can appeal to the head referee to have the penalty overturned. If in the opinion of the head referee and in consultation with league officials the video shows clear evidence that the penalty should not have been awarded then the penalty will be removed. If in the opinion of the head referee the appeal had no merit and the video does not provide any evidence that the penalty should be reversed an additional yellow card can be issued.

The Game

Introduction

This MineField game is designed to be a challenging and fun game. The point values for an optimal scoring strategy will not change but the value of other scoring items may increase to create other equally competitive strategies. In the interest of fairness and clarity, rules may need clarification or additional rules added during the season. The game will utilize differential scoring to determine the outcome of matches for sake of fairness and competition.

Game Description

A team consists of two robots and two drones that will be designated the red team or the blue team. Two teams will be scheduled to compete in two matches where each match lasts 10 minutes. The team will have multiple opportunities to score points by the mining of rubies and sapphires (ping pong balls) and depositing in designated containers, dropping an emerald from a drone into mineral container column, raising various objects with different sizes and values off the playing field, answering hidden science and math questions during the match, and placing rings on pegs in patterns. Robots will be placed touching the field perimeter on the designated team side, and drones will be placed within one meter of the field perimeter.

Autonomous Period

The first 60 seconds will be an autonomous period where robots and drones can score points without being under driver control. A robot or drone can start with one scoring item placed by a team member in contact with the robot or drone. Gold statues cannot be used as a placed scoring item at the start the of the autonomous period. Any points scored during the autonomous period will be added to the points scored during the operator controlled period. These points will then be calculated along with the rest of the points scored during the operator controlled period, along with the addition of the autonomous-specific points to determine multipliers.

Drone Autonomous

1. A drone after takeoff that lands at least two meters from the field perimeter will score 500 points
2. A drone after takeoff that lands on a designated team drone landing platform will score 2000 points
3. A drone after takeoff that lands in the corral will score 1000 points
4. A drone after takeoff that drops a gem in the drone loading platform will score 5000 points
5. A drone that can read a secret message in either the blue or red box will score 2500 points
6. A drone that can place a ring onto a peg will claim that peg for the match and score an additional 2500 points
7. A drone that can place a ring on the top of the mountain designated square will claim that square for the match and score an additional 2500 points

Robot Autonomous

1. A robot that moves at least two meters from the field perimeter will score 500 points

2. A robot that stops on a designated target will score 500 points
3. A robot that can score gems in a column will score 2000 points per gem
4. A robot placing a scoring element in a secure area on a scoring platform will earn points based on the height X cm multiplied by its value
5. A robot that can place a ring onto a peg will claim that peg for the match as well as score an additional 2500 points

Operator Control Period

During the operator control period, teams will have 9 minutes to perform mining related tasks that include clearing debris from the field and stacking valuable objects.

Secure Storage Areas

Each team has designated regions that allow valuable objects to be placed without the opposing team's interference and are marked as either red or blue. The team can place and stack objects on their designated regions during the match. Each team has a marked corner that is also considered a secure area. Drone landing platforms are an example of a secure space that can be moved, and teams can place items under or on top of the landing platforms. At the end of the match, the height in centimeters of the highest point of the scoring element on that resting surface will be multiplied by the value of the objects on that resting surface for points. If an opposing team is caught intentionally touching any items in a secure area or changing the value of stacked items, the team will get a 5X multiplier for the value of the stacked items in the secure area. If the height of the stacked items is disturbed, a team will be able to manually reconstruct the stack for maximum height with any objects within one meter of the perimeter of the secure area. In the event of a real or simulated natural disaster, no penalty will be applied to the secure area affected by such natural disaster.

Defense

Robots cannot intentionally play defense against another robot. Yellow or red cards will be issued for inappropriate interaction. Each robot will have a league provided balloon mounting device that sets the height of the balloon at a minimum distance from the field. Balloon must also have a 150mm clearance from any mechanisms that articulate up or out.The color of the balloon will represent the team color for that match. A drone can play defense by using its propellers to pop the balloon of an opposing team's robot. If a robot has its balloon popped it must immediately return to its pit area and have the balloon replaced. The robot, if attempting to score points at the time the balloon is popped must cease the attempt to score points and make every effort to return directly to the base. The league will provide the initial balloon for each robot at the start of the match. The first occurrence of a popped balloon will be replaced by another balloon provided by the league. If a robot has a second balloon popped it must return to base and will receive an empty balloon mounting device. That robot after two popped balloons and receiving an empty balloon mounting device will be immune from the defense the remainder of the match.

Boulder Clearing

At the end of the match, boulders that are cleared to the other side will earn the team points. For each small, team-colored boulder cleared to the other side at the end of the match will be worth 1000 points and each large team-colored boulder will earn 2000 points. Each team boulder that

is in the opposing team corral at the end of the match will score an additional 1000 points for the small team-colored boulder and 2000 points for the large team-colored boulder. If a team places all team-colored boulders of a particular size in the opposing team corral at the end of the match, they will score a bonus 10000 points for each set.

Road Clearing

Each oil drum will have a variable weight as indicated by the QR code placed on top of the drum. The oil drums can be stacked or hung and valuable points earned based on the value of the oil drum multiplied by the height in centimeters from the playing field. Oil drums that are stacked in an unsecured area can have a collision with other robots resulting in a loss of points for the stacking at the end of the match.

Mountains

At the center of the field is a structure shaped as a mountain with pegs extending towards home sides of each team's fields, with an opening 1200 mm x 670 mm, allowing a robot to drive through the mountain. Rings may be placed onto the mountain pegs in rows and columns for points. The more adjacent rings there are in a row or column, the higher the multiplier. At the center of the mountain, the scoring elements of silver, bronze, and gold can be "mined" by robots (detailed scoring and description on next page). Robots can pass through the mountain to the opposing side of the field if physically able to. At the top of the mountain are designated squares representing a 3 x 3 grid. A team that can place the most red or blue rings in a square at the end of the match will own that square and will become a designated team secure area. At the end of the match, each robot that has climbed the mountain and is not touching the field surface will be awarded 5,000 points. If two robots have climbed the mountain and additional bonus of 10,000 points will be awarded. For each drone that has landed on the mountain at the end of the match will be awarded 5,000 points. A drone that has landed on the peak of the mountain at the end of the match will be awarded an additional 5,000 points. If the peak of the mountain is a secure area designated by the number of rings on that surface then the airspace above that area will be considered home territory for determining if yellow or red cards should be issued as the result of a collision. If the peak is not a secure area then will be considered a neutral zone and no penalties awarded as a result of a collision between two drones.

Ramp Control

To the left and right of the mountain exists ramps that tilt to either the red side or blue side. As a ramp is driven across, it will tilt to the other side to allow movement back onto the ramp, while blocking the other side of the ramp. The ramps act as a one-way access point and can be manipulated by drones and robots. Each robot parked completely on the ramp at the end the match will be awarded 5,000 points. If two robots are on the same ramp an additional bonus of 10,000 points will be awarded.

Rare Minerals

The field is covered with rare minerals that if recovered and stacked will earn a team valuable points.

Emeralds

Teams will be given a supply of emeralds (Green ping pong balls) that must be delivered by a drone during the operator controlled period into the columns, used to collect rubies (Red ping pong balls) and Sapphires (Blue ping pong balls). A drone may only control one emerald at a time. A team will be awarded 2000 points for each emerald in a column at the end of the match and placed by a drone. For each emerald placed in a column will result in a 2X multiplier for that column with a maximum multiplier per column of 8X. Emeralds will not disrupt the purity multiplier placed on pure ruby and sapphire columns.

Ruby

The red team will be tasked with mining rubies (red ping pong balls) and sand (white ping pong balls) and placing them in any of the three columns. The approximate height in centimeters of the red and white ping pong balls will be multiplied by just the value of rubies and sand in the shortest goal. If the rubies and sand are placed in the medium goal a 2X multiplier will be used for the value of that column. If the rubies and sand are placed in the high goal a 5X multiplier will be used for the value of that column. If only rubies are placed in the column then a 10x multiplier will be used for the value of that column. Once placed in the column the height of the rubies and/or sand in the column represents one item.

Sapphire

The blue team will be tasked with mining sapphires (blue ping pong balls) and sand (white ping pong balls) and placing them in any of the three columns. The approximate height in centimeters of the blue and white ping pong balls will be multiplied by the value of sapphires and sand in the shortest goal. If the sapphires and sand are placed in the medium goal a 2X multiplier will be used for the value of that column. If the sapphires and sand are placed in the high goal a 5X multiplier will be used for the value of that column. If only sapphires are placed in the column then a 10x multiplier will be used for the value of that column. Once placed in the column the height of the rubies and/or sand in the column represents one item.

Gold

The gold in this area was long ago mined by an ancient civilization and the only gold that remains is in the form of gold statues and is considered very valuable. Gold must be placed in a team secure area to earn points for the value of the gold statue. A sacred gold idol, designated by a diamond, must be accessed by the AR catapult team, once released from the mountain a team may be placed in a secure area to earn points for the value of the gold statue. The use of the AR game can also trigger an avalanche, which can have unexpected consequences on a secure storage area.

Silver

In the middle of the field is a mountain that contains both silver, bronze as well as a gold statue. Teams should be careful as the mountain is very unstable and a landslide could deliver valuable material to the other team. Silver must be placed in a team secure area to earn points for the value of the silver multiplied.

Bronze

In the middle of the field is a mountain that contains both silver, bronze as well as a gold statue. Teams should be careful as the mountain is very unstable and a landslide could deliver valuable

material to the other team. Bronze must be placed in a team secure area to earn points for the value of the bronze.

Rings

On the sides of the mountain, facing the home field, are pegs extending outward that robots and drones can place rings onto. Points are scored by placing rings on to pegs in adjacent rows and columns without interruption; the more consecutive rings in an adjacent row or column without interruption increases the point multiplier by a factor of 1 (2 adjacent rings equals a 2x multiplier, 3 adjacent rings equals a 3x multiplier, etc). Rings are scored by multiplying a base value of 100 rope ring or 1000 per plastic ring based on the outer ring by the number of adjacent rings of the same color. A set of rings can also be placed on the summit of the mountain and will be considered as 4 pegs in a column for scoring. Summit and 4x3 Mountain pegs are independent of each other, multipliers do not overlap between the two. 10x multiplier if the entire 4x3 tree on one side is completely owned by one team. Rope rings can be pre loaded onto robots and drones, plastic rings must be picked up off the ring tree in the team's corresponding corner.

Science and Math Problems

Each team has a designated colored box that contains a monitor which displays science and math questions during the match. The science and math questions will come from standardized tests appropriate for the general grade level of the team. A new question will be displayed approximately every 30 seconds and a drone that is positioned at the opening can capture an image of what is displayed on the screen of the box using its camera. Team members can solve the math and science questions during the match for additional points. During the match, teams will write the question number and answer to each problem on one sheet of paper and submit it to the scoring referee immediately at the end of the match.

Table 1 Value of Scoring Items

Item	Value	Notes
Small Boulder	1000	At the end of the match on opposing teams side
Large Boulder	2000	At the end of the match on opposing teams side
Small Boulder in opposite team corral	2000	10,000-point bonus if all small boulders in opposing team corral
Large Boulder in opposite team corral	4000	10,000-point bonus if all large boulders in opposing team corral
Oil Drum	The marked value of the drum x 10 points	An empty drum will not earn points but can be used for increasing height of stacked items. The height measured in centimeters of the resting surface of each drum multiplied by the value of the drum.
Robot or Drone on the Mountain	5000	Two robots on the mountain an additional 10000 point bonus. A drone on the peak of the mountain an additional 5000 point bonus.
Robot on Ramp	5000	Two robots on the same ramp an additional 10000 point bonus
Emerald	2000	Adds a 2x multiplier to column for each emerald, max 8x
Rubies and Sand	100	Value multiplied by the height in centimeters of the settled stack
Rubies	500	Value multiplied by the height in centimeters of the settled stack
Sapphires and Sand	100	Value multiplied by the height in centimeters of the settled stack
Sapphires	500	Value multiplied by the height in centimeters of the settled stack
Gold	1000 10,000 Sacred Idol	The height in centimeters measured from the resting surface of the gold. Must be placed in team secure area
Silver	200	The height in centimeters measured from the resting surface of the gold. Must be placed in team secure area
Bronze	50	The height in centimeters measured from the resting surface of the gold. Must be placed in team secure area
Science and Math Problems	1000	A new question will be displayed every 30 seconds
Rings	100 Rope Ring 1,000 Plastic Ring	Rings are scored by taking the base value of the singular ring and multiplying by the number of adjacent rings in a given row or column. 10x multiplier if the entire 4x3 tree is completed.

Playing Field

TBA