Winning the International Botball Tournament: A Team Analysis

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Abstract— **This publication introduces a set of best practices for the educational robotics competition Botball gained through long standing experience in the subject. Furthermore the publication gives an historic overview of former Botball team items, the first non-US team to win the international Botball competition, and only the fourth to do so consecutively. The best practices were gathered by members of items over the course of a 4 year long competitive robotics career. With the publication of them, knowledge that can especially help new teams is made available to all Botball teams therefore lowering the barrier of entrance for new teams.**

The first part introduces the Botball competition and team items itself. This is followed by the 3 sections describing so called processes, each of them focusing on one area.

I. INTRODUCTION

Botball is one of the biggest school-focused robotics competitions in the world with over 250 participating teams from more than 15 countries. The aim of Botball has always been to use robotics to teach important STEM skills.[1] This effort cumulates in a competitive environment in which students show off their robots in fiercely fought rounds. Especially for schools with a long tradition in Botball, or those with the most knowledgeable students, a lot of the processes and knowledge required to be successful in a competition is already present. However, teams with no such history or students lacking the experience have a natural disadvantage as they miss important information and skills.

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Team items being one of the most recognisable Botball teams has gathered such skills and knowledge and therefore was able to successfully participate in various Botball competitions. By publishing this information, the Botball game might be lifted to a new level as new teams can acquire the theoretical knowledge needed to efficiently and effectively manage themselves.

The processes introduced were fundamental to items' success but should not be seen as absolute but rather one way to approach the competition, as many other teams have been successful with slight variations of the same techniques or even completely different approaches.

II. BOTBALL

Botball is a competition for autonomous robots organized by the KISS Institute for Practical Robotics (KIPR)[2]. The main objective is to design robots that perform a variety of tasks in 2 minutes.

Scoring is based on 3 major elements:

- Documentation
  3 Files showing a teams ability to document their progress have to be submitted through an online system and are graded. Also an on-site presentation has to be given.
- Seeding
  A team has 3 runs on the table to score as high as possible. The 2 best runs will be averaged for the score.
- Double Elimination (DE)
  Based on the seeding score a bracket for a double elimination tournament will be formed.

All 3 Parts contribute equally towards the overall score.[1]

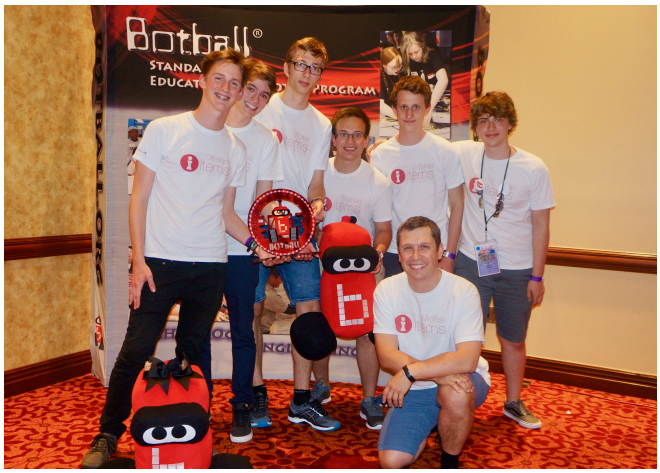

Fig. 1. items at GCER 2017

A. ECER

The European regional Botball tournament is organized by the Practical Robotics Institute Austria (PRIA), a Vienna-based organization for robotics education. As the tournament is part of the larger European Conference on Educational Robotics which is partly funded by EU grants, it travels around European countries.[4]

B. GCER

An international Botball tournament is organized as the Global Conference on Educational Robotics. The competitive program is extended by talks of famous researchers and networking events for students and teachers.[3]

III. Team

The team used as an example in this publication is items. Located in Wiener Neustadt, Austria items had 6 members and an overall active Botball career of 4 years. The members of the team were constant throughout this time with the dissolvement of the team on graduation of their members. All of the members were students of HTL Wiener Neustadt.

A. HTL Wiener Neustadt

HTL Wiener Neustadt is a technology focused 5 year long high school based in Wiener Neustadt. Consisting of 4 departments (civil engineering, computer science, electrical engineering and mechanical engineering) with the robotics club in the hands of the computer science department. Austrian technological high schools differ from normal high schools as they are 5 compared to 4 years long and have a major focus on technology and engineering with more than half of lessons being related to the department students enrolled in. This leads to students having more than average of theoretical and practical knowledge in their field of study.

B. History

items was founded in the first few months of the 2013/14 school year by 6 second-year students of the robotics clubs under the direction of Michael Stifter, PhD. The team members are Daniel Honies, Christoph Käferle, Daniel Swoboda, Markus Pinter, Florian Ungersbö”ock and Raphael Weinfurter. Starting with the 2014 Botball season items participated alongside veteran team AMAZeING at the European Regional Botball tournament in Vienna.

In the 2015 Botball season items participated in both the European regional torunament in Hollabrunn, Austria and the world championship in Albuquerque, New Mexico.

The 2016 season led to items becoming both European and World Botball champion in Vienna and St. Augustine, FL respectively.

Their age-related last season was in 2017, with participation at the European Regional in Sofia, Bulgaria and the second World Championship title at GCER in Norman, Oklahoma.

C. Successes

Competition	Overall	Seeding	DE
ECER 2014	4.	3.	7.
ECER 2015	3.	1.	13.
GCER 2015	5.	5.	6.
ECER 2016	1.	1.	1.
GCER 2016	1.	1.	1.
ECER 2017	2.	3.	3.
GCER 2017	1.	2.	1.

IV. Team Processes

In order to be a successful teams a variety of internal team processes have to be managed and planned out well. These processes are key regardless of the size of the team.

A. Motivation

While being successful at a competition and having fun while working on the robots is by itself a big factor in team motivation, there needs to be some sort of motivation management to overcome team-wide downs.

A big goal and achievable goal (e.g. Participating at GCER or being under the top 10 in Seeding at my regional) should be agreed on by all team members and worked towards together.

Team members lacking in motivation should always be encouraged by other team members to continue their work by highlighting the greater goal of the team and or recent successes in the development of the bots, be they very small.

Another big factor to motivation is a second in-house team. Having a constant measure in progress by a team working in the same environment can be a big deal whilst trying to stay motivated.

B. Organization and Management

There is no go-to solution for team organization as it varies on a lot of factors like resources, team size and team experience. However there are certain key factors that should be considered by all teams.

It is important to have either no person with more authority than others (democratic/anarchich approach) or a set of people with clearly defined authority that the whole team respects (captains approach).

Team members should communicate with their peers as much as possible, explaining decisions and avoiding an information void.

Roles should be clearly defined and work in small sub teams encouraged and favored over people working alone.

Meet-up dates should be clearly defined and attendance required. Frequently missing people and members working significantly more than others should be avoided as it may cause unrest.

Enough time should be dedicated. This needs to be adjusted based on team size, amount of robots and strategies, etc.

C. Division of Labor

With many unique characters with different possibilities coming together in a team, it is important to make sure that each talents are used as effective as possible. People working in their field of interest tend to do better on assigned tasks and come up with more creative solutions. That said, it should be encouraged in later stages of development that members of different fields of expertise engage with each other to boost creativity.

V. Pre-Competitive Processes

A. Strategy

1) Seeding: For the seeding strategy usually 2 team members studied the game review very carefully and at first only came up with a few tasks which would score very high and are not too risky. They then proposed those ideas to their other teammates and together the team figured out which tasks could be done by which robot.

By combining several lower scoring tasks instead of completing only one very high scoring task the risk of a strategy can be lowered drastically as the score will still be high even if one part fails. Furthermore the risk sinks if each robot solves scoring tasks solely and isn't depended on the other robot. At an optimum one robot would score at one side while the other one would score on the other side.

2) Double Elimination: In Double Elimination it is even more important to run consistent than in seeding. Therefore for their main Double Elimination strategy items usually adapted their seeding strategy only slightly so that all the adjustments for their seeding runs could be used in double elimination as well and they would only score on their side.

Whenever it was clear that the opponent team would stay on their side and not run a disruptor and their theoretical score was lower, items would trust their seeding bots and run a high scoring strategy.

In the event of another team running a disruptor bot, items would try to not run the bot which the disruptor is targeting but instead run a disruptor itself which would target the remaining bot of the opponent team. Following this concept, items has still one scoring bot while the other team has none. It is essential to not block vice-versa as the outcome would solely be based on luck which should be avoided at any circumstance.

Disruptor Bots: Disruptor Bots need to be either very big with long extendable arms or they need to have a creative way of overcoming the obstacles in the middle of the board effectively and fast. Both versions are very hard to achieve consistently and can take as long as a seeding strategy to develop even if they might look like surprisingly easy builds.

Anecdote: In the 2 GCER DE Tournaments items won, they only ran a disruptor in 2 final matches. A high scoring adaptable seeding strategy will usually get one way further than the most creative disruptor bot.

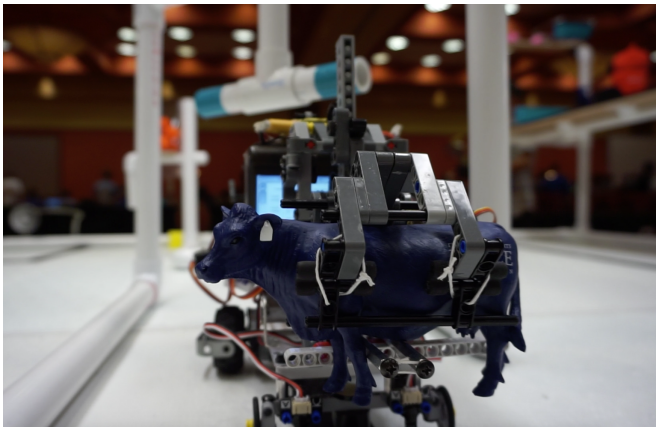

Fig. 2. Special claw mechanism used to grab the cow in the 2017 game

B. Documentation

The Botball Team Homebase provides very clear rules for the documentation phase. Also several examples of perfect documentations are given and very well commented. Therefore its very easy to score perfect on these and a minimal effort should be put to those if a team is serious about winning the tournament.

C. Robot Hardware

Items used a few core principles whenever a new robot was designed.

1) Robustness: Robustness is one of the most important principles when aiming for a consistent robot. If a robot isn't sturdy, its actuators won't have the same position every run. If it crashes, its actuators have to be re-calibrated. By using screws instead of connectors, legos can be connected more robust and whole subsystems won't fall off even if the robot encounters unexpected barriers during the run.

2) KISS Principle: Actuators are supposed to be build as simple as possible. This reduces the risk of mechanical failures and a more simpler LEGO construction is almost always sturdier than a very complicated one.

3) Specialization: Actuators that are modified exactly for one purpose can reduce programming time by magnitudes. There is a 1000 different ways to grab an object and usually the first try doesn't work best. Not being fixated on one solution and trying several different approaches might save time in the end.

4) Modulation: By building different subsystems for your robot which can be switched effortless, a lot of time building new robots can be saved while various strategies can still be realized.

D. Software Development

1) Pair Programming: Especially in later phases of the development of a bot, the people responsible for building the bots tend to have less tasks on their schedule. By working with them and using the concept of pair programming they can be a second set of eyes watching the bots as well as someone who critically questions decisions. This can help to find flaws in the strategy and the programming, therefore improving overall quality.

Making use of this programming strategy was key for a successful cooperation between the different sub-teams of items and a fast and reliable testing method.

2) Orientation and Positioning: Pipes are an easy way to align your robot. Especially in the corner of the game board they can be used to accurately achieve absolute positioning. This can reduce the amount of sensors needed and therefore remove factors of uncertainty from the strategy and program.

Pipe based orientation was used extensively by items.

3) Strategy Time Management: Managing the time dedicated to different parts of a strategy is one of the most important tasks in Botball. Items relied on multiple ways of managing the limited time available to the bots. One of the key aspects

was the use of multi-threading (as described later) and adaption of drive speeds. Both allow a vast reduction in time-consumption of a strategy. In order to synchronize the two bots on the table, time and sensor based events were used.

4) Fail-safes: In order to increase the performance and stability of a robot, items relied on fail-safes at critical points in the program. These fail-safes were activated when certain criteria were not met and activated a fail-safe program that either repositioned the robot or skipped to the next point of the routine.

Such a fail-safe can be critical for both Seeding and Double Elimination strategies and can safe a run from ending up in disaster. It is recommended to implement fail-safes.

5) Mulithreading: Multi-threading can be a core concept to save time and therefore a key factor to increase the amount of points that can be achieved. It's applications can vary from preparing the position of an actuator while the robot is moving to a different location to performing multiple tasks at the same time. It is however important to keep in mind that multi-threading can lead to unintended behavior and therefore requires mindful coding.

E. Consistency by Design

"complicated robots flash draw crowds on practice day, but simple reliability wins the tournament."

Consistency is a core fundamental of every aspect of a strategy and a robot. If testing shows that a sub-procedure cannot be repeated successfully 9 out of 10 times on your own table, it is too risky to be run at a tournament. Subsystems can be redesigned or a new strategical programming approach might work out. Sometimes adding a simple sensor can increase consistency a lot. If a system didn't work consistently after 2 weeks, it was usually dismissed and the strategy was modified.

F. Testing

Testing was usually done that one strategy would be programmed after another. The strategies would be programmed step by step, making sure the program works consistently before continuing with the next part. This approach safes a lot of time as a simple hard- or software change at the beginning can result in the whole program being needed to be recoded. Endless hours of testing showed that what worked best for the team was 2 people testing one robot. One being the primary programmer would compile and start the programs. The other is continuously setting up the table and robot. While the robot runs, both would together decide on what values need to be changed and what the next step for the robot should be.

VI. Competitive Processes

A. Effective Human Resource Management

To succeed at a tournament it is essential to use every member effectively in what they are best at and in a configuration where people can work together under stress without creating too much conflict.

The team had 4 people testing the robots in pairs as usual and 2 students focusing on information gathering. While one member keeps an eye on the testing table, the other one would have a closer look at the robots in the pit-area for possible construction violations.

It is essential for one student to get a general overview. They need to know most teams and their respective robots so they can later delegate on which teams to film in seeding or double elimination.

B. Information Gathering

During their four years of Botball items experimented with different ways of getting and storing the necessary information about other team's DE strategies necessary to win a tournament. It was tried to write everything down on paper by several people. In the second year the team even programmed a web application which stored the same information as the paper but with the added benefits of supporting pictures and videos. Ultimately after all of this approaches did not seem to provide critical information when needed and required an enormous amount of maintenance, the team settled with a way easier method:

For teams that were considered very good and where a special DE strategy was needed, the team tried to film them at seeding and store those files with the team name on one computer so they can be analyzed together later on.

During DE one or two people always monitored and mostly filmed the matches which where going to decide the team's next opponent. If the team wasn't one where a special strategy was created for, all members simply gathered together and decided on the basis of the just obtained information on which strategy to run.

C. On-Site

Items always put their presentation together based on the grading list given on the Team Homebase and printed it out on standard letter paper. It is advisable to double check especially on the graph and figures part as those score high and it is easy to lose points there.

Also bringing the grading list to the presentation is allowed and can help not forgetting any points that may not be in your presentation directly.

One should be able to score at least more than 95 points on the on-site if carefully prepared but its always hard to score perfect as you or the judges might miss a small detail.

VII. Conclusion

Botball is a dynamic and competitive environment. This publication and the insights shared through it are a first step into enabling younger and less-experienced teams to be more successful in a shorter amount of time. Such change would increase the overall competitiveness of the competition and therefore raise the level of knowledge acquired through participation for all teams. Upping the level of Botball therefore profits all teams, as it increases the complexity for experienced teams as well, who would have to face new challenges.

The authors would like to encourage more senior teams to release their insights, strategies and processes. Such information could then be made available in a knowledge-base for the benefit of all teams.

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References

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