Safety Measurements and Quality Issues in Botball

Bernd Veidinger, Matthias Grill, Linda Maschek, Joel Klimont, Konstantin Lampalzer, Alexander Lampalzer
Department for Computer Science
Secondary Technical College
Wiener Neustadt, Austria
Email: i14097@student.htlwrn.ac.at, i14076@student.htlwrn.ac.at, i14015@student.htlwrn.ac.at,
i14083@student.htlwrn.ac.at, i14085@student.htlwrn.ac.at, i14086@student.htlwrn.ac.at

***Abstract*—This publications reviews several safety, quality, and game issues encountered in this and the last year of Botball and proposes ideas, to fix this problems and lead to a better experience. There occurred problems that could harm the health of the users. This shall be avoided in any case, especially since many of the parts provided with the current or previous botball kit are also used in the junior botball challenge and occurring safety issues might harm children.**

***Index Terms*—safety hazards, quality issues, gameplay**

I. Introduction

This year, many problems and issues were encountered during the development phase by teams known to the author, which all led to undesired interruptions while writing code, costing precious time during development of the robot. Furthermore various kinds of technical problems wer identified, which represent a serious safety hazard for the user, for example exploding and burning batteries. These controllers and parts are also used in other challenges than botball like KIPR/PRIA Open [1] and the ”Junior Botball Challenge” [2]; in the latter one, the equipment is mainly used by younger students, as the name suggests. In this context it is an important aspect, that the used parts are safe to use and should have safety mechanisms, which should prevent them from causing damage even in case of possible misuse. A less important fact, which also causes significant time loss nearly every year for European teams, is that several parts to build game tables are available only from American vendors. As a matter of fact, some of these parts are even prohibited in Europe. This publication reviews some of these problems and offers solutions.

II. Issues Reviewed

A. Quality Issues

Quality issues, like broken servos or damaged parts, are time consuming while building the robots. The used controllers are buggy, or have parts inside, which break easily and cannot be exchanged by the user.

Many of the servos used in Botball broke during the seasons, without being under heavy loads or great stress. Some of them appeared to have manufacturing errors, which caused the servos to break down only after a few hours of operation. 1

There were also big problems with the KIPR Wallaby this year, in particular servo ports simply starting to malfunction. Servos would not stop rotating, some ports were only able to power one of the two kinds of servos available.They had not enough power to lift even small weights, nor could not be stopped rotating by the user, without disconnecting the battery from the Wallaby.

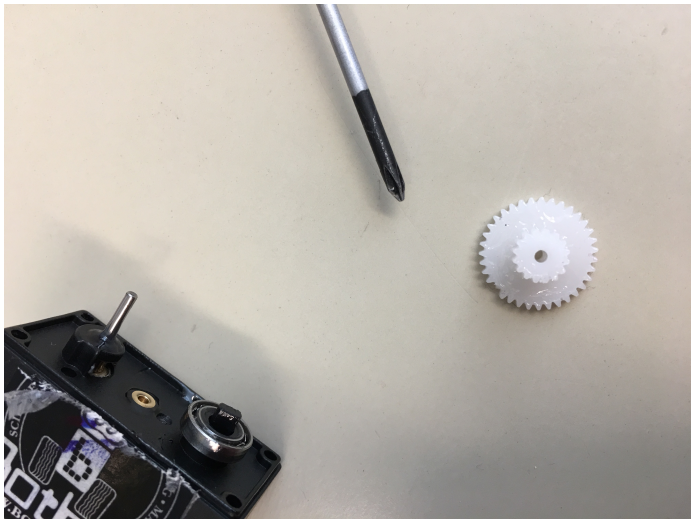

Fig. 1. Internal parts of broken servo

Furthermore servos (mainly used ones) can be very inaccurate compared to other ones. If they are compared to each other, there can be significant differences, which can be decisive, if teams have to replace broken servos during the tournament.

B. Safety Hazards

As previously indicated, Botball thrills many younger students to work on robots using the Botball kit, or parts of it. To ensure that they can work safely on their robots, safety issues should be fixed first. There are a lot of problems with batteries and charging devices and few of them can be quite dangerous. The charger for the KIPR Link [3] (which uses an internal battery) for example, is only available with the North American NEMA-1 plug and teams have to use an adapter to use it in Europe, which construction enables the user to touch unintentionally the metal contacts, while it is plugged into a power outlet. 2 A shock at 230V AC can (and in most cases will) be life threatening. [4] Furthermore, if a user pulls out a charger and touches the plug on the front of the charger, he will get a light shock, which is quite painful.

This could lead into the user dropping the charger, which could cause damage to both, the user and the charger.

Fig. 2. Open contacts on charger

There are a lot of problems with batteries, which have been encountered during the last two seasons. Two batteries started burning/smoking (one with the cell balancer dongle and one without) and one person got hurt while quickly removing the burning battery from the robot to prevent damage to the Wallaby or the bot. One battery exploded 3 while charging over night, which could have easily caused a fire at school, because the batteries were not in a "LiPo-Guard" bag (these bags were not recommended by KIPR) while charging. Cause of this explosion was the unintentional use of the old charger that was provided with the first type of batteries, which has not got a cell balancer built in.

Fig. 3. Puffed battery

C. Parts Not Available in Europe

If teams from Europe want to build a game table to practice at their school or laboratory, they have to import all the parts from the USA, because it's very difficult to get the right PVC-pipes at local dealers like hardware stores. They often only sell metric ones, but there are significant differences between metric tables and such, which are built from parts measured in US customary units. If a team is only able to build a table with local parts, their robot will have a big disadvantage unless they measure every distance to the PVC-pipes, they are driving towards to, or sideways to them. Using a metric game table at the local laboratory or school for testing and competing on a game table in the US measurement system means teams must adjust their whole code (distances, turns) to the new table, resulting in a time loss for testing other things. But this issue would also be persistent, even if only metrical game tables would be used. Also, the FRP base plates which are used as the floor of each table are prohibited in the European Union, because if they break, a fiberglass dust arises, which can cause pulmonary fibrosis when inhaled. [5] Delivery costs for FRP plates are extremely high when ordered from USA, because they are very large and do not fit on standard pallets (The FRP-Plates for example measure 4'x4').

In other educational robotics programs, for example RoboCup Junior [9], these problems do not arise, because the game tables use far less specific materials, which can be bought in every country, without the need of importing them. Controllers are widely available, because students are free to use every controller they want. A disadvantage when all controllers and parts are allowed is, that money can be a decisive advantage. If teams use the high end controllers and sensors to build their robots, it is far more easily to win for them.

III. Solving the Issues

A. Quality Issues

These types of problems can be easily solved. The main reason servos break is, that the small plastic gears inside are breaking easily. If they could be manufactured out of a more resistant material like PEEK (polyether ether ketone) [6], so they would not break so easily, but they might be a bit more expensive (which is relative, when teams do not have to buy multiple servos per season as a replacement). The issue with the broken servo ports on the Wallaby is quite more difficult to solve. Maybe KIPR could exchange the boards inside of the Wallaby against a Raspberry [7] or Banana Pi [8], so they can be easily replaced in case of damage, without sending the whole controller to KIPR, which takes a lot of time, if there is no backup controller to work with. When other types of controllers are used, custom electronics are needed, which also have to be provided by KIPR, if there are no additional electronic parts which can be accessed widely. Although it is a cheaper and easier solution to exchange only this parts, than exchanging the whole controller. Maybe there are possible solutions which are modular.

B. Safety Issues

Batteries should have internal safety circuits, which cut off the internal power connection in case the battery inside

the casing starts to expand. This could prevent fires, even if the battery is unusable after the circuits safety mechanism took effect. Furthermore, the cell balancer should be moved inside the battery, this would prevent charging or using the battery without it.This would be a difficult procedure to design and implement and KIPR would have to work with the manufacturers of the battery. When the Wallaby was initially released, it was delivered in combination with another type of battery, which uses a different type of charger that charges the battery directly over the XT60 plug. This type of battery does not require a cell balancer, the newer one, requires one indeed. If the two chargers get mixed up for some reasons, it also can lead to explosions of the new LiFe batteries. Regarding the Link chargers, maybe KIPR could offer an option to deliver it with a European charger, which does not require users to use an adapter between the power outlet and the charger. Another option to make the chargers compatible to multiple power outlets is by designing a new charger, on which the plugs can be swapped (like the larger Apple power adapters (iPad and MacBook)). Additionally, to reduce the hazard of a shock, the internal circuit of the chargers could be redesigned (by adding a LED for example), so the capacitors discharge correctly when the plug is pulled out.

C. Parts Not Available in Europe

This is potentially the difficult problem to deal with, is the acquisition and/or exchange of parts not available in Europe. The real issue behind it is, that teams competing at GCER come from different regions, in which different types of materials are sold. There can not only two types of tables be provided at GCER to cover all regions, but which table should be used when two teams from two different regions compete against each other? Which table should be used then? Consequently, it might be best to keep things like they are now in case of GCER. At ECER, it would be no problem to use metric unit game tables, which could make things easier and cheaper for all teams, because they would not depend on parts form the USA anymore.

IV. Conclusion

The authors of this paper do not intend to blame KIPR in any way but highlight the identified problems in existing kits. Moreover, some of the discussed issues are not only time consuming but also dangerous for users. We also identified several rather straightforward ways to solve all or most of these problems. We suggest that KIPR should consider making changes as indicated in this discussion paper, especially focusing on the issues which appeared unsafe to the users.

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