INTERCOLLEGIATE COMPETITION

in

ROBOTIC FOOTBALL:

A Proposal

August 2007

Summary. This project would result in a competition in which robots, representing their respective schools, would play the game of football, resulting in an eventual "national championship" each year.

Objective. This project would initiate a new intercollegiate competition in robotic football that combines the educational benefits of a technological competition with the passion of high-profile competition among university communities. The goals of this competition would include

- Encouraging the selection of engineering as an exciting and creative major
- Accelerating the pace of robot software and hardware development
- Enhance the field of engineering within college communities and the general public.

Background. Robotic sports competition offers a significant avenue for advancing robotic capabilities. The sports engaged so far have quite simple rules and roles for the robotic units. Existing competitions include:

- soccer (FIRA, RoboCup)
- one-on-one fights (RoboSumo, BattleBots, CNN RobotWars, Robotica)
- Botball
- Robo-One (MIT)
- MASLAB (Mobile Autonomous System Laboratory, MIT)
- AUSSI International Aerial Robotics Competition (Georgia Tech)
- FIRST (high school).

Some other robotic competitions pose significantly greater challenges, such as DARPA's autonomous robotic car Grand Challenge and the Robocon international design competition for remote control robots. Some of these competitions, such as the DARPA competition, did get momentary press coverage as it occurred. And television coverage of earlier, relatively crude, competitions did demonstrate the potential for "learning moments." But these competitions have not so far ignited wide public interest.

It is tempting to think how a robotic competition could begin to involve some of the nation's elite schools (such as, MIT, Carnegie Mellon, Chicago) into a true national, intercollegiate competition with both the excitement of the physical game of football and the intellectual challenge of advancing this technology.

Proposed Approach. The time appears ripe to create an ambitious robotic football competition. The competition would begin on a relatively modest scale and evolve as technology, funding, and interest permits. Notre Dame's engineering school faculty and students and a group of

outside supporters and advisers would first develop a set of parameters in which competition could begin within a few years. The major phases of development would likely be:

- Startup
- Refinement of rules
- Expansion of tournament competition
- Development of divisions of competition
- Evolution to open, multi-division competition
- Evolution to human scale, humanoid robots (if deemed feasible).

Startup. The startup phase is likely to require two years and consist largely of meetings. Startup efforts would have four elements: conceptual, rulemaking, technical, and funding. The conceptual committee is essentially a Steering Committee that discusses the big picture tradeoffs and decisions and synthesizes the efforts of the other teams. Decisions to be made by the Steering Committee include:

- Whether to write prescriptive rules in an effort to balance the playing field, or instead "let a thousand flowers bloom;" for instance, should the robots be required to be humanoid?
- Should the robots be autonomous or remote-controlled?
- Whether, initially, it makes sense to mimic eight-player football, common at more than 600 small high schools; another possible starting model would be scaled-down arena football.
- Dollar limits per team, if necessary.
- How to organize and initiate the competition. For example, how to involve other universities to participate in the rule-making and/or technical specification process. Teaming of universities in the early years will also likely make sense for funding and technical reasons. One school may develop the "quarterback," another, the linemen, etc.
- How the robotic national football champion is determined.
- Consideration of allowing non-university groups (companies, national labs, or other research centers) to team with a university (or multi-university team) in the formative years. The ultimate goal, however, is for stand-alone intercollegiate competition.

Reporting to the Steering Committee will be the Technical Team, which will develop specifications for

- The robots: dimensions, weight, cost, legs/wheels/either, possibly even specifying a common platform upon which to build the units in the earliest years (this appears to be the case for Botball)
- The team: such as number of robots, allowed differences (e.g., does the weight limit apply to each robot or to the team as a whole?). The technical team's goal will be to generate specs that are

achievable and meaningful for a football-like competition as soon as possible.

Also reporting to the Steering Committee is the Rules Team, whose purpose is to develop the rules of the game, which should follow the NCAA rules of football as closely as possible. Decisions to be made include:

- Tackling rules. Presumably, the rules will start with "touch tackling" evolving to something more will depend on technology developments.
- Passing rules. Similarly, passing may not be allowed in the early years. The Rules Team would have to work closely with the technical team to recognize the limitations of existing technology and will be open for change each year.
- Officiating. Generate guidelines for the referees officiating the games.
- From the beginning, the Rules Team should anticipate expansion in scale and scope toward large scale competition fields. Benchmarks along the way may include tennis court-size (perhaps half), basketball court-size, and football field-size. The relative dimensions of the fields will be kept as close as possible to actual football (roughly 160 by 300), eight-man football field (roughly 120 by 240), or arena football (85x150). The surface should be hard, green and demarcated with "yard markers."

The Funding Team, also reporting to the Steering Committee, will develop estimates of costs for the overall program, by year, for the first five years. With input from the Notre Dame faculty and this proposal, the team will approach several potential funding sources to develop initial seed funding. These targets will include private and public sources. Corporate funding beyond the initial general funding would likely be necessary for equipment, etc. The Steering Committee will ensure adequate resources and avoid having the outcome determined simply by the best fund-raiser.

For the public sector, candidate funding agencies would include DARPA, NASA, DOE, and NSF. Indiana state economic development funding (the Twenty First Century Fund) will also be sought. Foreign government funding will be explored if necessary to proceed (Korea's commitment to this technology option, for example, has been quite aggressive). Otherwise, such involvement will begin after the first ten years of competition.

At the conclusion of the startup phase, a four-team tournament championship will take place on the campus of Notre Dame as long as

this makes a positive contribution to the competition. The Rules Committee will decide where other elements of the tournament will take place.

Refinement of Rules. During the first competitive games, there is likely to be a need to revise rules. This will take place in a spirit of minimizing effects on the outcome, improving play quality, and limiting any unanticipated advantages that do not come from superior performance. The first phase of this rules revision process will occur in games not part of the tournament. If judged necessary, however, the rules revision process will continue during the first year tournament. Officials will observe play from the sidelines and any technology judged capable of helping the accuracy of officiating can be incorporated.

Expansion of Competition. The first dimension of expansion will be to add more competitors. After the first, four-team tournament, the field will be expanded to as many as 32 teams. Teams would be free to arrange scrimmages among themselves.

Development of Divisions of Expansion. After a few years of this scope, the Technical and Rules Committees will explore more expansion options. Teams may be added in the original division up to 64. After that number is reached, the potential for a pre-tournament season will be explored. Another dimension that will be explored is the development of another division, requiring fewer resources to participate, perhaps smaller size robots, non-humanoids robots, or fewer robots.

Human-scale Humanoid Robot Competition. The technical team will periodically assess the desirability of moving toward a final scale that would have human-scale humanoid style robots for the primary division.

*Championship***.** The national football robotics champion each year will receive the Brian Hederman Memorial Trophy.

Benefits to Engineering Education. This competition has the potential to generate significant fan interest, especially if the design of the competition takes account of creating an exciting experience for spectators, as well as participants. Based on earlier robotic competition experience, television coverage could create excitement and interest in engineering that could attract students, new appreciation/respect, and funds to the field.

Benefits to the Nation. Robots will play an increasingly important role in remote exploration (e.g., space, oceanic), emergency respone, and national security (at home and abroad). This competition will unleash

massive creativity about how to improve robotic effectiveness. It will also provide an excellent means for comparing various systems for responding to the unexpected (e.g., human remote control, autonomous robotic decision-making or multi-robot inputs for coordinated operations). It is not unrealistic to anticipate that this intercollegiate competition could advance robotics in a manner analogous to how academic interaction advanced DARPANET to the Internet.

Fields likely to benefit include:

- artificial intelligence
- decision science
- machine vision
- multi-agent systems
- robotic swarming
- SCADA
- humanoid robotics
- team communications systems
- adaptive machine learning
- image processing
- mechatronics
- human-machine interfaces
- robotic software platform development.