2 Game Description

2.1 Objective

Each team will design and prototype a robot for playing a modified game of Connect Four. Connect Four is played by dropping and stacking playing pieces (in this case balls of two different colours) into the top of a vertically-oriented board, in one of seven columns. Points will be awarded for each ball played, as well as straight links of 4 balls (linked vertically, horizontally, or diagonally). Traditionally the game is turn-based, but in this version each robot may play pieces as quickly and as often as they are able to. Game pieces (plastic balls) will be collected from each robot's exclusive territory and played at a common *gameboard* at the centre of the field. Gameplay will proceed for a set duration, and at the end of the time allotted the robot with the most points is declared the game winner. During the last week of classes all of the robots will compete in a tournament style design competition.

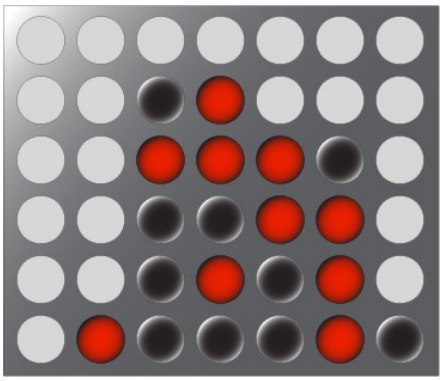

Figure 1: A traditional Connect Four game in progress.

2.2 Game Specifications

Examples of the game board, balls, playing field, and surrounding environment will be available to all teams during regular lab hours: inspection and experimentation is encouraged.

The game board will be comprised of seven columns. The columns extend from 2.5cm to 26.5cm from the ground plane of the playing field (sufficient space for six balls). The columns have a horizontal pitch of 4.5cm and are topped with a ramp to aid in the placement of the balls, and to reduce chance of interference with the opposing robot. Balls will be standard Ping Pong balls, coloured matte black or matte white, 4+/- 0.1 cm in diameter, weighing 2.7+/- 0.2 grams.

Figure 2 shows *one half* of the playing field with the gameboard located at the centre.The field will have a constant ground plane. The edges of the game board will be delineated by walls at least 7cm high. Game balls will be distributed in vertical-column *hoppers* throughout the playing field. The black side of the playing field will only contain black balls and the white side will only contain white balls.

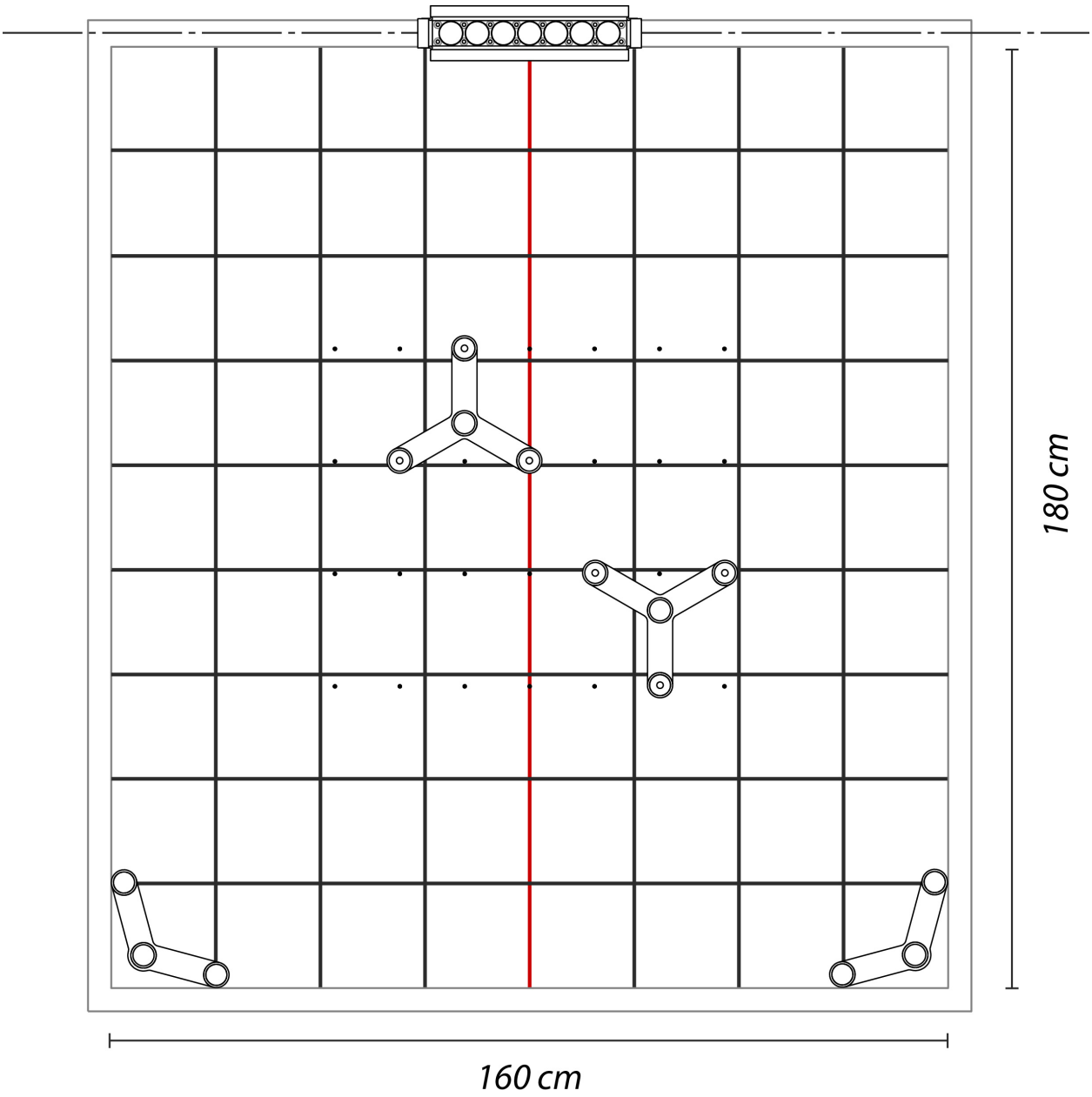

Figure 2: Single side of playing field

Two hoppers will be placed in the back corners and two hoppers will be placed semi-randomly in the 80cm x 80cm square in the centre of the playing field. The location of the central hoppers will be such that there is one hopper on each side of the field (left / right), and that sum of the distance between the hoppers and the gameboard is constant (ie. one hopper in the closest row, one in the farthest row, OR two hoppers in the centre row). Hoppers may touch the red centreline, but may not straddle it. Figure 4 gives examples of the possible locations. The locations on the white and black side of the field are symmetric (180 deg rotation about the field centre, instead of mirrored) such that the two competing robots see exactly the same problem. Each hopper has three legs of diameter 4.8cm, at a distance of 24.8cm centre-to-centre, with a clear plastic pipe in the centre. Balls fall down vertically and are held in place on the ground plane by bristles extending from the clear pipe. The hoppers in the back corner begin the game with 4 balls and the central hoppers begin the game with 7 balls. Hoppers do not get reloaded under any circumstance (ie. if balls are dropped or fall off the playing field). Other than the hoppers, there are no other obstacles on the field.

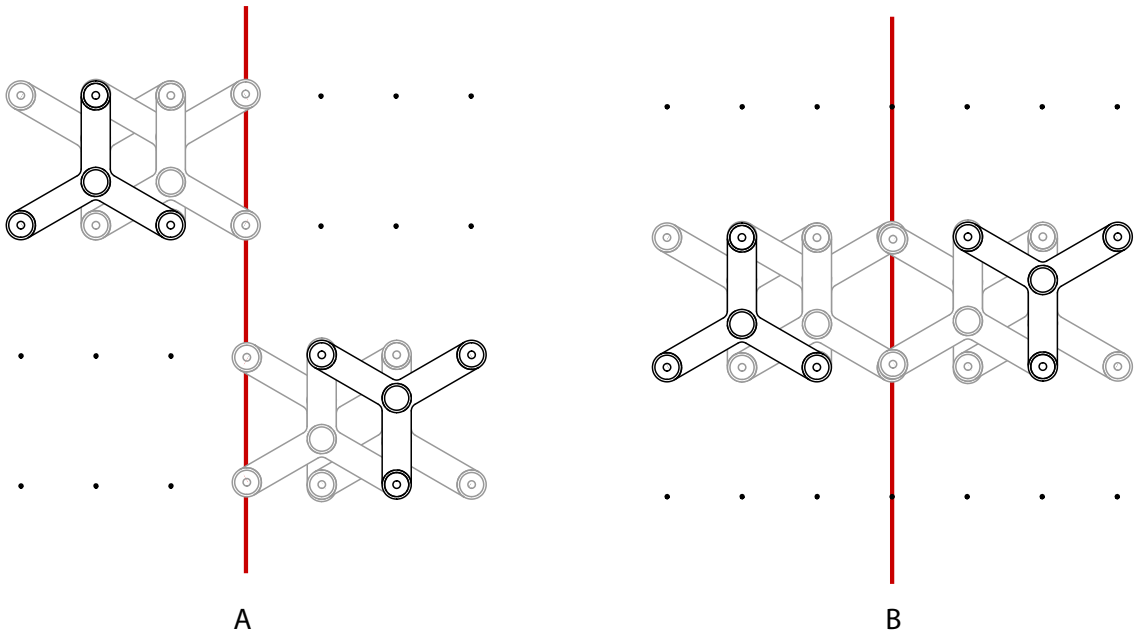

Figure 3: *A* shows the case where the *left* hopper is in one of four possible locations in the *first* row. In this case the *right* hopper must be in one of the four locations shown in the *third* row. *B* shows the case where the left hopper is in one of four locations in the *second* row. In this case the *right* hopper must be in one of the four locations shown in the *second* row, as long as the hopper legs do not occupy the same hole. A mirror image of *A* is also a possible set of hopper locations.

The floor plane of the playing field will be matte white and marked with matte black grid lines. Grid lines will be arranged perpendicular and parallel to the field mid-plane, of

width 1+/-0.3 cm and spaced 20cm centre-to-centre from the centre point of the field. The centre line will be red instead of black.

2.3 Gameplay Operation

Each robot begins in the 40cm x 40cm square that is against the back wall and on the red centreline of their side of the playing field. A black or white marking will be present near the start position for the robot to be able to determine which side of the board it is playing on. Orientation is at the player's discretion. Each team will be randomly assigned a colour 3 minutes prior to the start of the game. Upon game start, the player initiates operation of the robot.

Both robots will have 7-minutes of simultaneous play. The game ends after 7 minutes or when the gameboard is full. Each robot will need to collect balls from hoppers distributed on their half of the field and play them from their side of the game board at centre. Frequency of play is limited only by the performance of each robot, and is not turn-based. A ball may be played in any one of the 7 columns, and will drop to the lowest available position in that column (whether it be column-bottom or on top of another ball). Once a ball has been placed in the gameboard it may not be removed by either player, with the penalty being disqualification for the round. If opponents balls are removed they will be replaced by the overseeing Teaching Assistant as soon as possible.

Robots, however, may not *intentionally control* more than one gameballs at a time. *Control* is defined as either touching through direct or indirect contact, or using some near-field manipulation (such as air currents) to move a ball in a desired direction. Rolling a ball along the field (in the hopes of recovering it later) is *not* considered *control* once the ball has been released, but touching multiple balls when trying to corral them later would be disallowed. *Intentional* is defined as a deliberate action: a robot will not be penalized if it accidentally runs into a gameball that is rolling around the field. The exception is when pulling a ball from the hopper when the robot might come in contract with the ball above, and sensing the gameboard, where the robot might touch multiple balls, but not in an attempt to move them. Anything that that the team places on the field is considered part of the robot and governed by these rules. *Intentional control* of multiple gameballs results in disqualification for the round.

Robots my not *Intentionally interfere* with opposing robots. Deliberately launching game balls to the opponents side of the field is disallowed, but unintentionally losing a ball to the other side is not penalized. If a balls falls into the opponents side of the field it will be removed by the overseeing Teaching Assistant as soon as possible. Using fans or other devices near the gameboard that intentionally make it difficult for the opponent to play a ball is disallowed.

In order to avoid interference at the gameboard the following rule applies: No part of the robot, at any time, may cross the centreline of the field or be positioned such that a ball cannot be easily deposited into any column of the gameboard by a human hand. This effectively results in the an envelope restriction shown in Figure **??**, but also included the use of air currents or other devices to interfere with the opponent's play. Positioning a robot in such a way as to break this rule, at any point in the game, results in disqualification for that round.

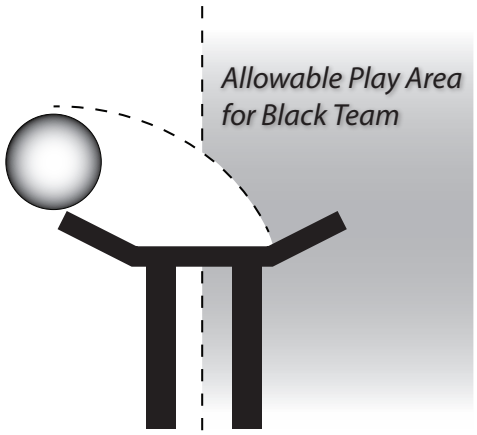

Figure 4: Shows the allowable envelope for the black team. The definitive test is whether or not a ball can be placed easily, by a human hand from the opposing side.

Robots may interact with the field, hoppers, gameboard and gameballs where possible, but may not permanently modify or deface it. The gameboard will remain fixed at field centre and hoppers may not be moved. Any damage to the gameboard or dislodging of the hoppers results in disqualification for the round, whether intentional or unintentional, and an immediate stoppage of play for that team (the opposing team may still continue).

In the case of any disqualification, play continues until the end of the 7 minute round, but the team scores zero points and deducts no points from their opponent for any connect 4's they have scored.

2.4 Constraints

- Robots must operate autonomously with no external input once the game is initiated.
- Microcontrollers may not be reprogrammed during the 3-minute pre-game phase, but, for teams of 3, information can be given via on-board data input methods. For teams of 4, no information can be given the the robot before gameplay other than the start command.
- Robots must be provided on-board power.
- Robots should be tolerant of accidental interference by their opponent.
- Robots must not damage playing balls during the game.
- Envelope: Prior to game start, the robot must not exceed an envelope of 40cm x 40cm x 40cm.
- Weight: The robot must not exceed a weight of 3Kg.

- Budget: The cost (as-purchased) of all components and materials utilized in fabricating the robot must not exceed $250CAD.
- Robots must have a safely-accessible STOP button that ceases robot operation immediately.
- The final robot must use properly soldered electronics and may not contain any breadboards.

2.5 Scoring

1 Point is awarded for each ball played in the gameboard. In addition, 4 points are awarded for each line of 4 or more balls (called a *set*), and 2 points are subtracted for each line of 4 that is scored by the opponent, with the limit that your score may not be lower than the number of balls you have placed in the gameboard. A line of 5, 6 or 7 balls earns the extra points for a completed set, but only counts as *one* single set. Examples are given in Figure 5. The full tournament structure is described in Section 3.6.2.

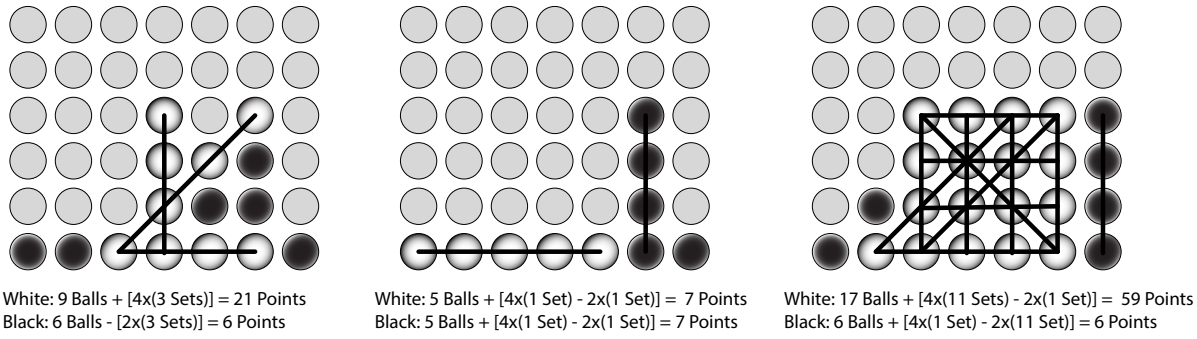

Figure 5: Various examples of how to score the gameboard. If the value within the square brackets is less than zero, it is considered to be zero so that your score may never be lower than the number of balls deposited.

2.6 Design Criteria of Solution

This environment has been constructed to reward excellent engineering design, good prototyping, and the use of strategy in gameplay. An optimal solution will give consideration to each of the following desirable qualities:

- Robustness & reliability
- Tolerance of uncertainty in the environment
- Elegance & aesthetics
- Speed & manoeuvrability

- Effective use of resources
- Cost
- Safety
- Portability

2.7 Statement of Work

Each team will be composed of three team members (more or less when necessary, at the instructors' discretion). Frequent communication is strongly advised between team members, to expedite and improve the integration process. Generalist knowledge is also encouraged in order to help fellow team members overcome challenges and obstacles. A suggested work breakdown is as follows:

Electromechanical Member: This member should be responsible for the overall hardware fabrication and integration of the robot. This includes the robot frame and mobility components, mechanical components and actuators, and fixtures for all of the circuits/sensors and microcontroller elements.

Circuits & Sensors Member: This member should be responsible for the electrical components of the system, including design/fabrication/integration of circuits for driving actuators, sensors for awareness of the environment, and power supply/distribution.

Microcontroller Member: This member should be responsible for the programming of the Arduino microcontroller and interfacing with inputs/outputs of the robot. The Arduino programming will heavily focus on system operation and autonomy, as well as gameplay strategy.