Development of Mechatronic Football Combine
Project III – Phase 2
Group 1

Introduction

The design specifications for a second generation mechatronic football league will be assessed through our proposed combine design concept. These specifications will directly influence the selection of motors, wheels, and other integral components during robot design. The combine is composed of seven drills that evaluate both basic performance as well as position specific criteria.

Overall Setup:

- **Location**: Stepan Center.
- **Date**: One week before final mechatronic football game.
- **Duration**: Assuming multiple setups for the Fumble, Impact, Endurance, Straightness, and Push tests, the combine should last approximately 2.5 hours. The duration of each specific drill is specified within the tests and drills section.
- **Scoring System**: Upon completion of a test, the performance of each robot will be assessed following the rubric given in Table 1. At the end of the combine, each player should have an average score of 0.75 points per test in order to successfully meet the design specifications.

<table>
<thead>
<tr>
<th>Test</th>
<th>1 point</th>
<th>0.75 points</th>
<th>0.5 points</th>
<th>0.25 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Test (lineman)</td>
<td>9 lbs</td>
<td>6.75</td>
<td>4.5</td>
<td>N/A</td>
</tr>
<tr>
<td>Push Test (skilled)</td>
<td>6 lbs</td>
<td>4.5</td>
<td>3</td>
<td>N/A</td>
</tr>
<tr>
<td>Fumble Test</td>
<td>4+ of 5</td>
<td>3 of 5</td>
<td>2 of 5</td>
<td>1 of 5</td>
</tr>
<tr>
<td>Impact Test</td>
<td>tackle sensor activates</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Straightness Test</td>
<td>≤ 10° deviation</td>
<td>≤ 20° deviation</td>
<td>≤ 30° deviation</td>
<td>N/A</td>
</tr>
<tr>
<td>Quarterback Test</td>
<td>&gt; 80 ft</td>
<td>&gt; 75 ft</td>
<td>&gt; 70 ft</td>
<td>&gt; 65 ft</td>
</tr>
<tr>
<td>Kicker Test</td>
<td>4+ of 5</td>
<td>3 of 5</td>
<td>2 of 5</td>
<td>1 of 5</td>
</tr>
<tr>
<td>Endurance</td>
<td>5 min</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Tests and Drills

Fumble Test

- **Purpose:**
  - To test design of robots’ gripping mechanisms.
- **Applicability:**
  - For quarterbacks, running backs, receivers, safeties and defensive backs.
- **Procedure:**
  - The test will consist of 5 trials. In each trial, the robot will start 2 feet from a concrete wall, holding a football in its gripping mechanism. It will accelerate straight until it hits the wall. All robots will take the test simultaneously.
- **Scoring:**
  - Robot will score 1 point for at least 4 successful trials.
  - 1/4 of a point will be deducted for each dropped ball thereafter.
- **Resources Required:**
  - 1 robot operator.
  - 1 ball and robot setup person.
  - 16 footballs.
- **Time Estimation:**
  - 100 seconds (conservatively, 2 minutes).
    - 15 sec to reset/prepare next trial (each trial).
    - 5 sec to run test and record data (each trial).

Impact Test

- **Purpose:**
  - To confirm soundness of motor selection and weight.
- **Applicability:**
  - For all robots.
- **Procedure:**
  - The test will consist of 5 trials. In each trial, the robot will start 6 inches from a concrete wall. It will accelerate straight until it hits the wall. All robots will take the test simultaneously.
- **Scoring:**
  - Robot will score 1 point for at least 4 successful trials.
  - 1/4 of a point will be deducted each time the 5-pound tackle sensor does not register the collision.
- **Resources Required:**
Endurance Test

**Purpose:**
- To ensure battery life will enable full game play.

**Applicability:**
- For all robots.

**Procedure:**
- The test will elevate robots and run them at full speed for 5 minutes. Robots will be placed adjacent to each other on 3 pairs of wooden planks, which will hold them up on their bottoms, near the outside edges such that the wheels are free to rotate (fig. 1). There will be 6 robots per set of planks. Robot controllers will activate full motor power on the timer's command, and hold full power until the 5 minutes has expired.

**Scoring:**
- This is a pass / fail event. Robots must be running at full speed after 5 minutes to pass. Robots receive 1 point for passing, and failure results in disqualification from play.

**Resources Required:**
- 6 4”x4”x8’ wooden planks.
- 16 robot controllers.
- 1 timer.

**Time Estimation:**
- 6.5 minutes.
  - 1 minute to place robots on the planks.
  - 30 seconds for controllers to get set.
  - 5 minutes to run the test.
**Straightness Test**

- **Purpose:**
  - To determine the accuracy with which a dual motor system can be controlled by angular velocity sensors, and thus tests the ability for the robot to proceed in a straight line.

- **Applicability:**
  - For all robots.

- **Procedure:**
  - The goal of this drill would have the robot moving down a 20 foot straight line, with a human controller only commanding “forward” (no controller steering). The straightness will be quantified by observing the difference in angle between the straight line and the angle of the final direction at the end of the 20 feet. Small cones will be set up along a line at the distance of 20 feet, (fig. 2) and scoring will reflect the deviation of the robot by assigning point values to the different zones the robot will pass through.

- **Scoring:**
  - The robot will score 1 point if it deviates less than 10 degrees.
  - The robot will score 0.75 points if it deviates between 10 and 20 degrees.
  - The robot will score 0.5 points if it deviates between 20 and 30 degrees.
  - The robot will receive no points for deviation greater than 30 degrees.

- **Resources Requires:**
  - 1 robot operator.
  - 1 robot setup person.
  - Cones and Tape measure.

- **Time Estimation:**
  - 50 seconds (conservatively, 1 minute)
    - 30 sec to reset/prepare next trial (each trial).
    - 20 sec to run test and record data (each trial).

![Figure 2: Straightness Test Set-up](image-url)
**Push Test**

- **Purpose:**
  - The push test simply tests how much force a player can impart on another player.
  - This skill will be necessary in order to tackle an opposing player for the defenders and for blocking on offence.
  - The push test gives design constraints for motor torque and wheel grip.

- **Applicability:**
  - For all robots

- **Procedure:**
  - Each player will be set up with the forward direction against a spring (fig. 3).
  - They will then push with all of the force they can to displace the spring as much as possible.
  - The displacement measured in the spring allows the calculation of the force by the robot so be simply $F = k \cdot x$.

- **Scoring:**
  - Skill players should be able to impart 6 lb, and linemen should be able to give 9 lb.
  - A player meeting or exceeding this criteria will receive 1 point. A force 75% of the above values will receive .75 points, and a force 50% of the above will receive .5 points. Anything less than 50% of the target value will be awarded zero points.

- **Resources Required:**
  - 1 robot operator.
  - 1 person to measure maximum displacement of the spring.

- **Time Estimation:**
  - 2 minutes per robot.
    - 1 minute for setup.
    - 1 minute for test.

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*Figure 3: Power Test Set-up*
**Throwing Quarter Backs – Passing Challenge**

- **Purpose:**
  - The passing challenge is a method to test a quarterback’s “arm” strength as well as accuracy. It will be necessary to throw the ball for distance, but accuracy will be of utmost importance if a viable passing game will exist.

- **Applicability:**
  - For throwing quarterbacks only.

- **Procedure:**
  - The passers will be placed at a starting line. There will be a measuring line straight in front of them, perpendicular to the starting line.
  - The throwers will launch the ball as far as they can, but as close to the straight line as possible. The first contact of the ball with the ground will be marked.
  - As depicted in Figure 4, the distance along the measuring line, \(d\), will be measured along with the error from the straight line, \(e\).
  - Each player will attempt 3 passes. The final score is calculated by summing the values of \((d - e)\).

- **Scoring:**
  - A player who totals 80 feet or greater will earn one point, 75 feet will earn 0.75 points, 70 feet will earn 0.5 point, 65 feet will earn 0.25 points, and less will earn no points.

- **Resources Required:**
  - The controller of the robot will set it up pointed the correct direction as well as controlling the robot.
  - 1 person will be needed to mark where the ball lands and measure the distances.

- **Time Estimation:**
  - 5 minutes per robot.
    - 1 minute for setup.
    - 4 minutes to throw and measure 3 attempts.

![Figure 4: Passing Challenge Set-up](image)
**Kicker Test**

- **Purpose:**
  - To evaluate the kicking mechanisms that will be used during the game.

- **Applicability:**
  - For kickers and punters.

- **Procedure:**
  - The test will require that each robot intending to kick during the game attempt 5 kicks.
  - Each kick will be taken from a distance of $\frac{94}{3}$ feet from the goal line.
  - A successful kick will be considered one that travels between the goal post hash marks and lands beyond the goal line.

- **Scoring:**
  - 1 point towards the player's final score will be awarded for 4 or more successful kicks.
  - 0.75 points will be awarded for 3 successful kicks.
  - 0.5 points for 2 successful kicks.
  - 0.25 points for 1 successful kick.

- **Resources Required:**
  - 1 robot operator.
  - 5 footballs.
  - 1 goal line referee.

- **Time Estimation:**
  - Total time: 2 minutes per kick (conservative estimation)
    - 30 second setup time, which may include placing the ball in a tee.
    - 1 minute to run drill.