Automated Guided Vehicle Project

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MME 101
Automated Guided Vehicle (AGV)

Background
Most companies earn profits by producing or adding value to products which involves having raw materials enter and finished products leave a facility. Many products have thousands, or even millions for an airplane, of parts needing to be received, inventoried, allocated, and assembled. Having all the right parts in all the right places at all the right times is no easy task. Robots are very helpful and common in this process. While robots in the form of automated guided vehicles move these parts around, robots in the form of arms assemble via welding, bolting, etc. Design, fabrication, and programming of all these robots is an interesting and challenging responsibility for many engineers. The engineer’s job frequently has complex and contradictory constraints which must be addressed to arrive at an optimal solution. Constraints typically include things like cost, weight, speed, size, flexibility, reliability, safety, and attractiveness. While we can’t address all these issues here in this class, we will try to simulate reality the best we can.

Project
Each team will design, fabricate, and program a functioning automated guided vehicle (AGV) to perform a specified task in the class at the completion of the project. Grades will be based upon execution of the task, vehicle size, weight, appearance, and completion time while obeying all rules. Team member contributions will also affect grades.

Details
Teams
Teams of five students will be assigned either a Lego (http://mindstorms.lego.com/en-us/history/default.aspx and http://www.ni.com/academic/mindstorms/) or VEX (http://www.vexrobotics.com/vex-classroom-lab-kits-cortex.html and http://www.vexrobotics.com/easyv4.html) kit from which the AGV will be constructed. It is strongly recommended that each team member take ownership of a specific aspect of the project such as design, fabrication, programming, testing, etc. Team skills such as planning, communication, scheduling, and effectiveness will be important. Team members will rate each other for contributions and effectiveness.

Production Facility Lay-out
Companies have a wide variety of facility lay-outs. While optimization of these lay-outs is important, for this task the lay-out is specified and the AGV is focus of our design project. The lay-out has two storage bins (labeled 1 and 2 each ~3 inch/7.5 cm diameter by ~4 inch/10 cm high), four locations (labeled A, B, C, and D), three steel poles (~2 inch/5 cm diameter by ~6 inch/15 cm high), and defined routes (~2 inch/50 cm wide) between them. See Figure 1. Dimensions of the facility, in cm, are shown in Figure 2.

At the beginning of the test, your AGV is in location A, storage bin 1 is in location B, and storage bin 2 is in location D. Poles can be used for location indicators.

Figure 1: Production facility lay-out.
Task
Each AGV must follow the route at all times and complete the Task shown below in four (4) minutes or less (less time results in a better grade):

1) Starting from region A, move storage bin 1, initially in region B, to region C.

2) Move storage bin 2 from region D to region B.

3) Move storage bin 1 from region C to region D.

4) Return to region A.
An information video showing this Task sequence can be found on YouTube: [http://goo.gl/pN6Yh](http://goo.gl/pN6Yh)

**Project Constraints**

During the test of the AGVs, while performing the above Task, the following constraints apply:

1) Only one builder set per team is allowed. No extra material can be used except cable ties or rubber bands, which require prior approval.

2) Regardless of the builder set contents, only three (3) motors, two (2) touch sensors, and one (1) light sensor can be used in design and fabrication of the AGV.

3) The AGV must fit with the perimeter of region A (a square with sides 15.75 inch/40 cm) with a height less than 12 inch/30 cm.

4) Weight, speed, route, and other requirements as identified below in Rules and Grading.

**Rules**

During testing the following Rules apply:

1) The AGV must complete the Task autonomously (i.e., no remote control). Once the AGV is activated, any touching by the team counts as a ‘restart’ and must start again in the original configuration.

2) Each team is allowed a maximum of three (3) restarts.

3) The AGV will be stopped at a time of four (4) minutes if the Task has not yet been completed.

4) The AGV must follow the routes between regions using sensor feedback at all times. If the AGV loses the route, a restart from the original configuration is required.

5) The storage bins must be entirely within the outer perimeter of the region or a restart from the original configuration will be required.

6) If the AGV knocks over or moves the poles, a restart from the original configuration will be required.

7) Any robot designs or programs deemed too similar to other team’s AGVs will be required to provide an explanation and lower scores or disqualification may occur. Secrecy for proprietary ideas is recommended.

**Grading**

Team scores for the AGV project will be determined as follows for teams successfully completing the Task while satisfying all Constraints and Rules:

\[
\text{Score} = 0.3 \times (\text{time rank}) + 0.5 \times (\text{weight rank}) + 0.2 \times (\text{cool rank})
\]

Where

- time rank = 10 for fastest, 8, 6, 4, 2, and 0 for slowest teams (Tests will be timed)
- weight rank = 10 for lightest, 8, 6, 4, 2, and 0 for heaviest teams (AGV will be weighed)
- cool rank = 10 for coolest, 8, 6, 4, 2, and 0 for least cool (student votes will be counted)

0.3, 0.5, and 0.2 = weighting per design priority so total score = 10 maximum
Team AGV scores drive grades for those teams successfully completing the Tasks within the Constraints without breaking the Rules. Successful teams will either earn 10 pts (A, highest 50% of scores) or 8.5 pts (B, lowest 50% of scores). Teams not completing the Tasks and/or with Constraints or Rule problems will get between a maximum of 7 pts and minimum of 0 pts. Each student grade may be shifted downward if their project contributions are poor. Students making no contribution will receive 0 pts.

It is hoped that the top three team scores will receive prizes: $250 to the team with the highest score, $100 to the second placed team, and $50 to the third placed team. Fundraising is underway.

**Test Details**

The AGVs will be tested in ECC 111 on Tuesday, 10/16, and Thursday, 10/18, starting at **7:30 am**. All Lego tests will be done on 10/16 and all VEX tests on 10/18. More details will be announced later.

**Lab Access and Etiquette**

The AGV lab is in ECC 103A and will be open MWF 8:00 – 10:45 am and TR 6:00 – 8:00 pm for consulting, fabrication, and programming. Technical help will be available during open time lab times.

No food or beverages in the lab. Wash hands before entering. Keep the parts organized. Some parts may be sharp and there may be pinch points in some AGV designs.

Lego and VEX instructional tutorials with useful links are available on D2L.

**Schedule**

It is recommended that each team meet the following schedule of intermediate events to successfully complete the AGV project. Teams can be checked out in the lab during open hours whenever the team is ready. Teams not meeting these dates may be required to explain reasons.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate mastery of three programming goals or elements</td>
<td>9/17</td>
</tr>
<tr>
<td>Present drawings (or a detailed concept sketch) of your design</td>
<td>9/24</td>
</tr>
<tr>
<td>Demonstrate mastery of fabrication/programming/sensor interaction</td>
<td>10/1</td>
</tr>
<tr>
<td>Demonstrate mastery of a portion of the required Tasks</td>
<td>10/8</td>
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</tbody>
</table>

Helpful videos explaining programming goals or elements:


**Hints**

1) Plan as a team before lab. Meet regularly to discuss ideas and progress.

2) Come to lab weekly to learn, get ideas, and get motivated.

3) Read and reread this handout carefully regarding dates, Tasks, Constraints, and Rules.

4) Review videos on YouTube or other locations on the web.

5) Try to fabricate, program, and run the AGV early so it successfully completes the Tasks. Then, try to optimize the AGV by increasing speed and decreasing weight.

6) Don’t neglect other course work. Fit this into your schedule using a priority-based plan.