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Faculty of Engineering, Environment and Computing

7073CEM – Robotics: Kinematics, Dynamics and Applications

Assignment Brief

Module Title	Individual	Cohort	Module Code
Robotics – Kinematics, Dynamics and Applications		SEPJAN	7073CEM
Coursework Title (e.g. CWK1) Trajectory Tracking Control of a differential drive robot			Hand out date: 31th Oct 2023
Lecturer Dr Andrew Jason Tickle, Dr John Arvanitakis			Due date and time: Date: 15th November 2023 Online: 18:00:00
Estimated Time (hrs): 30 Word Limit*: N/A	Coursework type: Literature Review, Computer Simulation		Credit Value assessed. 5
Submission arrangement online via Aula: Submission via Turnitin by 18:00 File types and method of recording: Submit a PDF File with the file name being your Student ID Mark and Feedback date (DD/MM/YY): Mark and Feedback method (e.g. in lecture, electronic via Aula): Detailed written feedback when asked			

Module Learning Outcomes Assessed:

1. Model and simulate different locomotion mechanisms that enable a mobile robot to move unbounded throughout its environment and the motors and associated driver principles.
2. Evaluate different robotic models and the kinematic control and sensor systems used by these models.

Exercises on Differential Drive Robot (70 Marks)

1) Using the template code that was given, simulate a differential drive robot with a baseline of $b = 0.14m$ and using the following velocity profiles for simulation time $tstop = 20sec$ **(5 Marks)**:
   i. $v = 0.8\ m/sec, \omega = 0.8\, rad/sec.$
   ii. $v = 0.4\ m/sec\,,\ \omega = 0.4\, rad/sec.$
   iii. $v = 0.4\ m/sec\,,\ \omega = 0.8\, rad/sec.$
   iv. $v = 0.8\ m/sec\,,\ \omega = 0.4\, rad/sec.$

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2) Simulate the robot again, by using the limits of the wheel velocity. Compare each case with the respective one in Exercise 1 **(15 Marks)**.

3) Assume the trajectory for a differential drive robot that is given from the following equations:

$$x(t) = \alpha \cos(kct)\cos(ct)$$
$$y(t) = \alpha \cos(kct)\sin(ct)$$

For the values of $a = 1, k = 3, and\ c = 0.1$, modify the code to instead calculate the inverse kinematics of the robot. Simulate the robot given that trajectory for simulation time $tstop = 30$ and without considering the limits on the robot velocities **(10 Marks)**.

4) For the velocity profiles given in Exercise 1, implement the dead reckoning algorithm. Present in each case the errors between estimated robot position and actual robot position and comment on the results. For which case does the Dead Reckoning present the maximum error? **(20 Marks)**

5) Change the loop time according to the values given below. For each case re-run the simulations for the velocity profiles in Exercise 1 and compare the results. How does the loop time affect the error of the algorithm? **(20 Marks)**
   i. $t_s = 0.05\ sec$
   ii. $t_s = 0.1\ sec$
   iii. $t_s = 0.01\ sec$

Exercises on Car like WMR (30 Marks)

6) Simulate the **rear** wheel driving robot for the following velocity profiles for $\ell = 0.1m$ and $tstop = 25sec$ **(15 Marks)**:
   i. $v_1 = 0.2\,m/sec\,, v_2 = 0.05\,rad/sec$
   ii. $v_1 = 0.2\,m/sec\,, v_2 = 0.02\,cos(0.5t)\,rad/sec$
   iii. $v_1 = 0.3\,m/sec\,, v_2 = 0.05\,cos(0.5t)\,rad/sec$

7) For the velocity profiles in Exercise 2, re-run the simulations for the following cases of wheel distance ℓ:
   i. $\ell = 0.1\ m.$
   ii. $\ell = 0.15\,m.$
   iii. $\ell = 0.2\,m$

   Compare each case and comment on the differences (if any) of the resulting trajectory **(15 Marks)**.

Notes:

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1. You are expected to use the Coventry University APA style for referencing. For support and advice on this students can contact Centre for Academic Writing (CAW).
2. Please notify your registry course support team and module leader for disability support.
3. Any student requiring an extension or deferral should follow the university process as outlined here.
4. The University cannot take responsibility for any coursework lost or corrupted on disks, laptops or personal computer. Students should therefore regularly back-up any work and are advised to save it on the University system.
5. If there are technical or performance issues that prevent students submitting coursework through the online coursework submission system on the day of a coursework deadline, an appropriate extension to the coursework submission deadline will be agreed. This extension will normally be 24 hours or the next working day if the deadline falls on a Friday or over the weekend period. This will be communicated via your Module Leader.
6. You are encouraged to check the originality of your work by using the draft Turnitin links on Aula.
7. Collusion between students (where sections of your work are similar to the work submitted by other students in this or previous module cohorts) is taken extremely seriously and will be reported to the academic conduct panel. This applies to both courseworks and exam answers.
8. A marked difference between your writing style, knowledge and skill level demonstrated in class discussion, any test conditions and that demonstrated in a coursework assignment may result in you having to undertake a Viva Voce in order to prove the coursework assignment is entirely your own work.
9. If you make use of the services of a proof reader in your work you must keep your original version and make it available as a demonstration of your written efforts.
10. You must not submit work for assessment that you have already submitted (partially or in full), either for your current course or for another qualification of this university, with the exception of resits, where for the coursework, you maybe asked to rework and improve a previous attempt. This requirement will be specifically detailed in your assignment brief or specific course or module information. Where earlier work by you is citable, i.e. it has already been published/submitted, you must reference it clearly. Identical pieces of work submitted concurrently may also be considered to be self-plagiarism.

Mark allocation guidelines to students (to be edited by staff per assessment)

0-39	40-49	50-59	60-69	70+	80+
Work mainly incomplete and /or weaknesses in most areas	Most elements completed; weaknesses outweigh strengths	Most elements are strong, minor weaknesses	Strengths in all elements	Most work exceeds the standard expected	All work substantially exceeds the standard expected

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Marking Rubric (To be edited by staff per each assessment)

GRADE	ANSWER RELEVANCE		ARGUMENT & COHERENCE		EVIDENCE		SUMMARY	
First **≥70**	Innovative response, answers the question fully, addressing the learning objectives of the assessment task. Evidence of critical analysis, synthesis and evaluation.		A clear, consistent in-depth critical and evaluative argument, displaying the ability to develop original ideas from a range of sources. Engagement with theoretical and conceptual analysis.		Wide range of appropriately supporting evidence provided, going beyond the recommended texts. Correctly referenced.		An outstanding, well-structured and appropriately referenced answer, demonstrating a high degree of understanding and critical analytic skills.	
Upper Second **60-69**	A very good attempt to address the objectives of the assessment task with an emphasis on those elements requiring critical review.		A generally clear line of critical and evaluative argument is presented. Relationships between statements and sections are easy to follow, and there is a sound, coherent structure.		A very good range of relevant sources is used in a largely consistent way as supporting evidence. There is use of some sources beyond recommended texts. Correctly referenced in the main.		The answer demonstrates a very good understanding of theories, concepts and issues, with evidence of reading beyond the recommended minimum. Well organised and clearly written.	
Lower Second **50-59**	Competently addresses objectives, but may contain errors or omissions and critical discussion of issues may be superficial or limited in places.		Some critical discussion, but the argument is not always convincing, and the work is descriptive in places, with over-reliance on the work of others.		A range of relevant sources is used, but the critical evaluation aspect is not fully presented. There is limited use of sources beyond the standard recommended materials. Referencing is not always correctly presented.		The answer demonstrates a good understanding of some relevant theories, concepts and issues, but there are some errors and irrelevant material included. The structure lacks clarity.	
Third **40-49**	Addresses most objectives of the assessment task, with some notable omissions. The structure is unclear in parts, and there is limited analysis.		The work is descriptive with minimal critical discussion and limited theoretical engagement.		A limited range of relevant sources used without appropriate presentation as supporting or conflicting evidence coupled with very limited critical analysis. Referencing has some errors.		Some understanding is demonstrated but is incomplete, and there is evidence of limited research on the topic. Poor structure and presentation, with few and/or poorly presented references.	
Fail **<40**	Some deviation from the objectives of the assessment task. May not consistently address the assignment brief. At the lower end fails to answer the question set or address the learning outcomes. There is minimal evidence of analysis or evaluation.		Descriptive with no evidence of theoretical engagement, critical discussion or theoretical engagement. At the lower end displays a minimal level of understanding.		Very limited use and application of relevant sources as supporting evidence. At the lower end demonstrates a lack of real understanding. Poor presentation of references.		Whilst some relevant material is present, the level of understanding is poor with limited evidence of wider reading. Poor structure and poor presentation, including referencing. At the lower end there is evidence of a lack of comprehension, resulting in an assignment that is well below the required standard.	
Late submission	0		0		0		0	