

# Your Project Title

Your Name

**Abstract**—Write your abstract here.

**Index Terms**—Write up to three keywords about your work.

## I. MANUAL MOTION OBSERVATION

The goal of this experiment is to design a differential drive robot using LEGO EV3 and then measure its pose variation for three different constant velocity motions: an arc to the left, straight line ahead, and an arc to the right.

### A. Design of Experiment

PUT DESIGN IMAGES AND TEXT HERE AND HOW TO MEASURE POSE AND ENSURE START POSITION

### B. Estimates of the expected Precision

PUT ERROR DUE TO MEASUREING HERE

### C. Jacobian Error Propagation

Let  $F$  be a vector function to calculate the end pose using two measured positions,  $\mathbf{x}_1$  and  $\mathbf{x}_2$ . The definition of these input vectors and the function can be seen in Equations 1 to 3.

$$\mathbf{x}_1 = \begin{pmatrix} x_{1,1} \\ x_{1,2} \end{pmatrix} \quad (1)$$

$$\mathbf{x}_2 = \begin{pmatrix} x_{2,1} \\ x_{2,2} \end{pmatrix} \quad (2)$$

$$\mathbf{F}(\mathbf{x}_1, \mathbf{x}_2) = \begin{pmatrix} \frac{1}{2}(x_{1,1} + x_{2,1}) \\ \frac{1}{2}(x_{1,2} + x_{2,2}) \\ \arcsin \frac{x_{2,1} - x_{1,1}}{\sqrt{(x_{1,1} - x_{2,1})^2 + (x_{1,2} - x_{2,2})^2}} \end{pmatrix} \quad (3)$$

To propagate the error from measurements of  $x_1$  and  $x_2$  the Jacobian matrix  $\mathbf{J}$  needs to be calculated. Here, the Jacobian matrix  $\mathbf{J}$  is a  $2 \times 4$  matrix which can be seen in Equation 5.

$$\mathbf{J} = \begin{pmatrix} \frac{\partial F_1}{\partial x_{1,1}} & \frac{\partial F_1}{\partial x_{1,2}} & \frac{\partial F_1}{\partial x_{2,1}} & \frac{\partial F_1}{\partial x_{2,2}} \\ \frac{\partial F_2}{\partial x_{1,1}} & \frac{\partial F_2}{\partial x_{1,2}} & \frac{\partial F_2}{\partial x_{2,1}} & \frac{\partial F_2}{\partial x_{2,2}} \\ \frac{\partial F_3}{\partial x_{1,1}} & \frac{\partial F_3}{\partial x_{1,2}} & \frac{\partial F_3}{\partial x_{2,1}} & \frac{\partial F_3}{\partial x_{2,2}} \end{pmatrix} \quad (4)$$

$$= \begin{pmatrix} \frac{1}{2} & 0 & \frac{1}{2} & 0 \\ 0 & \frac{1}{2} & 0 & \frac{1}{2} \end{pmatrix} \quad (5)$$

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†Supervised by Supervisor 1 (Affiliation) and Supervisor 2 (Affiliation)

‡Submitted in Month 20XX

### Error Propagation Formula

The covariance matrix of the result  $\mathbf{C}_F$  is related to the covariance matrix of the inputs  $\mathbf{C}_x$  by the formula:

$$\mathbf{C}_F = \mathbf{J} \mathbf{C}_x \mathbf{J}^T$$

where  $\mathbf{C}_x$  is the  $4 \times 4$  covariance matrix for the input vector  $\mathbf{x} = (x_{1,1}, x_{1,2}, x_{2,1}, x_{2,2})^T$ .

- The diagonal elements of  $\mathbf{C}_F$  give the **variances** of  $F_1$  and  $F_2$ :  $\mathbf{C}_F(i, i) = \sigma_{F_i}^2$ .
- The off-diagonal elements of  $\mathbf{C}_F$  give the **covariances** between  $F_1$  and  $F_2$ .

## REFERENCES

- [1] M. Mustermann and J. Smith, "Some Title," in *Some Conference*, 2023, pp. 1–8.

## ACKNOWLEDGMENT

Write your acknowledgments here.

## STATEMENT OF ORIGINALITY

[If AI assistants have not been used, use this sentence] I, the undersigned below, declare that this work has not previously been submitted to this or any other university and that it is, unless otherwise stated, entirely my own work.

[If an AI assistant has been used, use this sentence] I, the undersigned below, declare that this work has not previously been submitted to this or any other university and that it is, unless otherwise stated, entirely my own work. The report was, in part, written with the help of the AI assistant [AI assistant name] as described in the appendix. I am aware that content generated by AI systems is no substitute for careful scientific work, which is why all AI-generated content has been critically reviewed by me, and I take full responsibility for it.

Date

Signature

## APPENDIX

Please limit the main part of the report to 20 pages (not including the references, the statement of originality, and the appendix).

In your appendix, you can add any additional details about your work, such as:

- extra results that do not necessarily belong in Sec. ??
- more detailed justifications of certain algorithm design decisions
- algorithm proofs

Additionally, in the case of using AI assistants, describe in detail what content was generated using an AI assistant. In particular, name the AI assistant(s) that you used and how they were used (e.g. which prompts were used, and for which parts of the project).