

Project Milestone 4 – Algorithm Refinement and Final Deliverable

Instructions

1. Read this document carefully. You are responsible for following all instructions in this document.
2. Read the Learning Objectives at the end of the document to understand how your work will be graded.
3. Use professional language in all written responses and format all plots for technical presentation. See EPS01 and EPS02 for guidelines.
4. Good programming standards apply to all m-files.
5. Submit deliverables to Gradescope. Name your files to match the format in the table below, where *SSS_TT* is your section and team ID (e.g., 001_03 is Section 001, Team 3)

Item	Deliverables
M4 Answer Sheet	M4_AnswerSheet_SSS_TT.pdf
M4 Algorithm	M4_Algorithm_SSS_TT.m
M4 Main Function	M4_Main_SSS_TT.m
Technical Brief	M4_TechnicalBrief_SSS_TT.pdf

See submission requirements on the last page of this answer sheet.

6. Complete the Assignment Header before starting the answer sheet.

Assignment Header

Section and Team ID (SSS_TT): 002_02

Team Member Name	Purdue Career Account Login
Connor Damato	Damato0@purdue.edu
Kush Gogia	Kgogia@purdue.edu
Jack Swingle	Jswingle@purdue.edu
Matthew Imm	Mimm@purdue.edu

Role of Each Team Member

In this section, put each team member's name who worked on this milestone. In the Detailed Description of Work, each person on the team should write their own description of how they contributed to this milestone. Be very detailed here. Then in the last column, your team should estimate the percentage of the work that each team member did on the milestone. This column needs to add up to 100%. We know that on any given milestone that this will vary, but one person in the team should not be doing significantly more than the others throughout the whole project. Use this column as a way for you to make sure your workload is balanced throughout the project.

Team Member Name	Detailed Description of Work	Percent of Work
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Matthew Imm	Reviewed what was missing from our M3 and evaluated our strengths. Wrote the feedback and summary plan.	25
Connor Damato	Helped fix the V0 and Vmax functions. Calculated percent error for the M3 and M4 algorithms. Worked on technical brief.	25
Jack Swingle	Helped fix V0 and Vmax functions. In charge of putting it all together in the main function. Worked on technical brief.	25
Kush Gogia	Helped debug code and try variations for our Vmax function. Worked on technical brief.	25

Part 0: M3 Feedback Review

Reflect on your M3 feedback for the purpose of improvement. Your reflection should provide a clear, useful summary of your M3 feedback and provide a clear and practical plan to address the issues. Complete Table 1 below.

Table 1. Feedback summary and plan

<p>Part A: Based on your feedback from M3, identify at least one strength and one limitation of your team's work in M3. Consider how the feedback you received on M3 could lead to improvements in your work.</p> <p>One strength of our M3 was our algorithm improvements. We were able to adjust our algorithm to have a higher degree of accuracy for all of the parameters. Before our improvement we did not have all of the parameters within the accepted range, however after we redesigned our algorithm all of the parameters were well within the accepted range. One limitation of our M3 was the lack of references included in our report. It is important to show references when doing a project and going forward we will improve our referencing. Based on the M0 memo from March 21, we have a clear algorithm and have begun our analysis of said algorithm, which is a strength in the direction we will take our project, focusing mostly on improvements than new development.</p>
<p>Part B: Explain how you will incorporate the M3 feedback to improve your parameter identification (do not just reword your response from Part A; include concrete actions you will take).</p> <p>In our M3 submission, not all of our parameters fell within the accepted range. In order to improve our algorithm we made the following changes:</p> <p>We changed our slope calculation from a "polyfit" function to the slope formula $(y_2 - y_1) / (x_2 - x_1)$ in order to be able to control our y-intercept. We made our y-intercept 0 which solved a lot of our problems.</p> <p>As well as the change to the slope formula, we also added more values for our algorithm to run through to test in order to calculate v0 more accurately.</p>

Part 1: Algorithm Improvements Plan

Respond to each of the prompts below in the space provided. Your goal is to introduce the **two improvements** to your M3 algorithm. Use your ideas from Part 3 of M3 to help formulate ideas. Briefly describe, in words (not code), the nature of the improvements you will implement in your MATLAB code. Provide a brief, but thoughtful, description of your refinement, using evidence-based rationales for why the refinement is necessary and should improve your solution. Read the rest of this document carefully **before** you begin your work on this milestone. Once you are ready to begin Part 1, put your refinements and your rationale in Table 2.

Table 2. Algorithm refinement plans

Refinement 1
<p>Parameter(s) Targeted: V0</p> <p>Description</p> <p>Our V0 values were continuously underestimated. This is because our algorithm found the best r^2 line for the entire data instead of trying to get the smallest accurate domain to get the line.</p>
<p>Rationale for Refinement</p> <p>This improvement is necessary because if we continuously underestimate the values, we will also underestimate our Km values. This means if our company is comparing it to its competitors Km values, ours might be low.</p>
Refinement 2
<p>Parameter(s) Targeted: Vmax</p> <p>Description</p> <p>The Vmax value was extremely underestimated, most likely because we were using the Vmax as the maximum value of the calculated v0s instead of calculating it from the linearization.</p>
<p>Rationale for Refinement</p> <p>The improvement is necessary because incorrect Vmax values can reduce the accuracy of the model, causing the K values to be off the mark, so fixing this will help reduce our error by a large amount.</p>

Part 2: Algorithm Refinements Implementation

Before you make any changes to your code, resave your M3 code files as

- M4_Algorithm_SSS_TT.m
- M4_Main_SSS_TT.m

Implement improvements in M4_Algorithm_SSS_TT.m. **Clearly comment where you made improvements within the code, using the text 'Improvement 1' or 'Improvement 2' and a concise, meaningful description of the change for each improvement.**

Do not delete any code as you implement the improvements: comment out unnecessary code and comment on the change. Clearly indicate where new code is added with the commenting described above.

Evaluate the improvements in your algorithm by using the data for the reference enzyme PGO-X50 from M3. Compare the parameters identified for the PGO-X50 data using the algorithm you submitted in M3 and your refined algorithm for M4. This step ensures that you can compare the percent error of your algorithm known values of the data. Report your results in Table 3. Use appropriate decimal places.

Table 3. Algorithm refinement comparison

Parameter ($\mu\text{M/s}$)	PGO-X50 Reference Values	M3_Algorithm	Percent Error between PGO-X50 and M3_Algorithm (%)	M4_Algorithm	Percent Error between PGO-X50 and M4_Algorithm
v_{0_1}	0.025	.0223	10.8	.0257	2.80%
v_{0_2}	0.049	.0476	2.86	.0507	3.47%
v_{0_3}	0.099	.0870	12.12	.0992	0.20%
v_{0_4}	0.176	.1555	11.65	.1755	0.28%
v_{0_5}	0.329	.3030	7.9	.3341	1.55%
v_{0_6}	0.563	.5179	8.01	.5611	0.34%
v_{0_7}	0.874	.7967	8.84	.8435	3.49%
v_{0_8}	1.192	1.051	11.9	1.1291	5.28%
v_{0_9}	1.361	1.2249	10	1.2935	4.96%
$v_{0_{10}}$	1.603	1.4607	8.88	1.5163	5.41%
V_{max}	1.806	1.4607		1.6501	
K_m (μM)	269.74	238.93		241.36	

Next, use your M4 algorithm to analyze the full 100 enzyme test data sets and obtain the parameters V_{max} and K_m . Here you will run your M3 algorithm and your updated M4 algorithm on the full data set. You may need to make adjustments to both algorithms to account for the replicate data sets and 5 enzymes. In Table 4, record your results from both your M3 and M4 algorithm. Use appropriate decimal places.

Table 4. M3 and M4 algorithm comparison of experimental data parameters

Enzyme	M3 Algorithm			M4 Algorithm		
	Enzyme Parameters		Percent Error	Enzyme Parameters		Percent Error
	V_{max} ($\mu\text{M/s}$)	K_m (μM)		V_{max} ($\mu\text{M/s}$)	K_m (μM)	
NextGen-A	0.8664	150.82	2.70%	0.9342	150.82	9.04%
NextGen-B	0.7042	301.45	4.64%	0.8635	353.15	6.32%
NextGen-C	1.0818	191.87	5.09%	1.1980	187.44	10.86%
NextGen-D	1.3589	272.27	4.27%	1.5886	296.64	6.24%
NextGen-E	1.4768	170.35	3.23%	1.5933	157.94	6.91%

(Note: our percent error was determined using the midpoint of the range of acceptable values)

In Table 5, include any references you used throughout this answer sheet for Parts 0-2. Use APA format. Make sure there is an in-text citation for all references listed and vice versa.

Table 5. References used in Parts 0-2 (if any)

Lion, Avery D. <i>Enzyme Analysis</i> . Personal Communication. 2022, March, 21

Part 3: Technical Brief

Consult the M4 memo from NaturalCatalysts, Inc. for the details concerning your technical brief. Use the provided template M4_TechnicalBrief_template.docx to respond to the memo. You may find the original introduction memo and the project background documents helpful when composing your technical brief.

Part 4: Résumé Insert

In response to the opportunity presented in the NaturalCatalysts memo, create an insert for your résumé by completing the following on this answer sheet:

Guidance:

Summarizing your ENGR 132 project for your résumé

Choose a header and specific language to describe your project. Possible Headers for Engineering 132 Project Descriptions include: Engineering Projects, Design Projects, Related Experience, Engineering Experience. The specific language should be “action” oriented and highlight both the project and your contributions to it. Your project title should be something that describes this project.

Template:

HEADER

Project Title, Purdue University

Semester YYYY

- Power Verb (Skill) + Identifiable task + Purpose/Method/or Result
- Power Verb (Skill) + Identifiable task + Purpose/Method/or Result
- Power Verb (Skill) + Identifiable task + Purpose/Method/or Result

Example:

DESIGN PROJECTS

Autonomous Lawn Mower, Purdue University

Spring 2020

- Improved sensor technology resulting in increased safety and reduced cost
- Developed MATLAB code to optimize sensor performance and to perform constraint analysis
- Constructed and tested a functional prototype that surpassed industry standards

Things to keep in mind:

- Headers should stand out (Bold/Underlined/Larger Font and/or CAPS).
- Do not use “Engineering 132” Project as the project title. Prospective employers will not know what that title means. Give the project a descriptive name.
- Differentiate between project title and location using style change or location variance.
- Separate the location and the date of the project. Placing the date on the right side of the page is common, but not required.
- Your 3-5 bulleted statements should all maintain the *same tense* (past if previously completed, or present if currently working on).
- Begin each bullet with a different power verb.
- For these 3-5 statements, try to answer the questions “What did you do?”, “How did you do it?”, and “What was your result?”

Resumé Text: In the space below, write a **summary of your project suitable for inclusion on your resumé**. Be sure to use the guidelines above regarding formatting and language. A resumé typically includes 3-5 bullet items describing a project. The stems for your bullet points should be power verbs that convey what you did on the project (i.e., implemented, led, developed, analyzed, etc.). Use your individual versions from the video activity to create a team version here.

Engineering Project-Based Learning

Natural Catalysts Inc. Data Analysis, Purdue University

Spring 2022

- Coordinated team-based algorithm development to create a data analysis program
- Applied MATLAB coding skills to solve problems
- Identified sources of error to create the best possible solution
- Communicated results via professional technical brief

Finally, you should each add this insert or your individual one from the video activity into your own resumé.

How to Submit

1. Save this answer sheet as a PDF named **M4_AnswerSheet_SSS_TT.pdf** where **SSS** is your section number (e.g., 001 for section 001) and **TT** is your team number (e.g., 07 for team 7).
2. Save your technical brief document as a PDF named **M4_TechnicalBrief_SSS_TT.pdf**.
3. Select one person to submit the deliverables for the team. That person should
 - a. Log into Gradescope and submit all deliverables to the **M4** assignment.
 - i. M4_AnswerSheet_SSS_TT.pdf
 - ii. M4_Algorithm_SSS_TT.m
 - iii. M4_Main_SSS_TT.m
 - iv. M4_TechnicalBrief_SSS_TT.pdf
 - b. Select all team members for the group assignment and submit.
 - c. Double-check that all team members are assigned to the submission.
4. Each team member should confirm that they are part of the submission.
5. After submission, distribute the submitted files to all team members. *Ensure all members of the team have copies of the submitted files.*

Learning Objectives

Teamwork (TW)

Contribute to team products and discussions

TW02. Document all contributions to the team performance with evidence that these contributions are significant.

Process Awareness (PA)

Reflect on both personal and team's problem solving/design approach and process for the purpose of continuous improvement.

PA01. Identify strengths in the approach used.

PA02. Identify limitations in the approach used.

PA03. Identify potential behaviors to improve approach in future problem solving/design projects.

Idea Fluency (IF)

Generate ideas fluently. Take risks when necessary.

IF03. Generate testable prototypes (including process steps) for a set of potential solutions.

Evidence-Based Decision Making (EB)

Use evidence to develop and optimize solution. Evaluate solutions, test and optimize chosen solution based on evidence.

EB01. Test prototypes and analyze results to inform comparison of alternative solutions.

EB03. Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions.

EB05. Present findings from iterative testing or optimization efforts used to further improve aspect or performance of a solution.

EB06. Clearly articulate reasons for answers when making decisions or evaluating alternative solutions.

Solution Quality (SQ)

Design final solution to be of high technical quality. Design final solution to meet client and user needs.

SQ01. Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions.

Information Literacy (IL)

Seek, find, use and document appropriate and trustworthy information sources.

IL04. Include citations within the text (in-text citations) that show how the references at the end of the text are used as evidence to support decisions.

IL05. Format reference list of used sources that is traceable to original sources (APA or MLA are recommended)

Engineering Professional Skills

PC05. Fully address all parts of assignment by following instructions and completing all work.

EPS01. Use professional written and oral communication.

EPS02. Format plots for technical presentation.

Programming

MAT01. Develop code that follows good programming standards.

- MAT05. Create and use MATLAB scripts and functions.
- MAT08. Debug scripts and functions to ensure programs execute properly, perform all required tasks, and produce expected results.