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):	002-21

Team Member Name	**Purdue Career Account Login**
Griffin Hentzen	Ghentzen
Will Stonebridge	Jwstoneb
Chris Panagis	Cpanagis
Trevor Matovina	tmatovin

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
Griffin Hentzen	Was responsible for Parts 0 and 1: reviewing feedback from M3 and planning the incorporation of the feedback into our algorithm. This includes describing exactly what the team will do to improve each parameter we choose to focus on. Also worked in the technical brief on introduction point 3: to identify three decisions made to improve the algorithm during our entire process.	25%
Will Stonebridge	Was responsible for the creation of the main function. Additionally, was tasked with adapting the algorithm and plot construction UDFs to fit the scheme of the program. Responsible for the Description of the parameter identification in the technical brief along with the results section	25%
Chris Panagis	Was responsible for updating the algorithm for use in m4 and implementing the new improvements. Was also responsible for in the technical brief: (description)	25%
Trevor Matovina	Was responsible for part(s) __: (description). Was also responsible for ___ in the technical brief: (description)	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

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. Based on M3 feedback, one strength of our algorithm was its overall quality. The grader stated numerous times that our work was of high quality and all work was done to the quality expected. One weakness of our team's work was the plots could have been spaced better. Given this feedback, the team could consider improving the spacing of our plots in the future. This would improve the output display while maintaining our strengths.
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). The team can implement this by plotting each graph in its own figure, rather than crowding all graphs into one figure in different subplots. This would be done using the figure() command rather than the subplot() command.

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
Parameter(s) Targeted: V0, Vmax, Km Description *The team's M3 algorithm found the first 50 points of each concentration column and calculated the slope using those points, which gives us the initial velocity of each curve.. Our improvement is to reduce the number of points from 50 to 33.*
Rationale for Refinement • *This improvement would give us a more accurate initial velocity since it would capture less of the curved data and hopefully only give us the slope of the most linear trend in the data.* • *33 points was chosen because we believed 33 to be still high enough to yield a statistically relevant answer.* • *By correcting the V0 values, our Km and Vmax will also become more accurate, as they are predicted based on V0s*
Refinement 2
Parameter(s) Targeted: V0, Vmax, Km Description *Our second improvement was to smooth the concentration data using the MovMean function. This would mitigate against noise.*
Rationale for Refinement *Our data had variation and did not follow an exact trendline, so there was obvious error in our calculated values in M3.* • *MovMean allows users to smooth data without using the smooth function, which is prohibited* • *Smoothing data should allow for better V0 values (which are currently predicted using data that contains noise).* • *Better V0 data would allow for more accurate Vmax and Km values because they are calculated using the initial velocities.*

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 error of your algorithm to a known error in the data. Report your results in Table 3. Use appropriate decimal places.

Table 3. Algorithm refinement comparison

Parameter (µM/s)	PGO-X50 Reference Values	M3_Algorithm	M4Algorithm
v_{0_1}	0.025	0.024	0.026
v_{0_2}	0.049	0.047	0.050
v_{0_3}	0.099	0.096	0.107
v_{0_4}	0.176	0.171	0.185
v_{0_5}	0.329	0.327	0.334
v_{0_6}	0.563	0.546	0.597
v_{0_7}	0.874	0.855	0.927
v_{0_8}	1.192	1.203	1.197
v_{0_9}	1.361	1.399	1.306
$v_{0_{10}}$	1.603	1.578	1.550
V_{max}	1.806	1.87	1.70
K_m (µM)	269.74	287.69	239.51
SSE $(\mu M/s)^2$	0.0048	.0161	.0121

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		SSE $(\mu M/s)^2$	Enzyme Parameters		SSE $(\mu M/s)^2$
	V_{max} (µM/s)	K_m (µM)		V_{max} (µM/s)	K_m (µM)	
NextGen-A	1.09	176	.0184	1.07	173	.0156
NextGen-B	.94	352	.0021	.93	367	.0022
NextGen-C	1.34	197	.0028	1.23	188	.0014
NextGen-D	1.72	311	.0054	1.60	292	.0035
NextGen-E	1.81	175	.0132	1.62	163	.0099

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)

None Used

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: Resumé Insert

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

Guidance:

Summarizing your ENGR 132 project for your resumé

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.

PROJECTS

NaturalCatalysts Enzyme Analysis, *Purdue University*
Summer 2021

- Improved sensor technology resulting in increased safety and reduced cost
- Efficiently developed various of charts in order to display our kinetic enzyme testing data to our client
- Comprehensively collaborated within our team in order to create different MATLAB functions to implement into our final algorithm.
- Recognized spaces of improvement throughout our algorithm in order to enhance our final design.
- Performed parameter identification through various enzymes using nonlinear regression in order to organize our data in our algorithm.

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.