# Project Milestone 4 – Algorithm Refinement Answer Sheet

## 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 and to Blackboard. 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 | Project\_M4\_AnswerSheet\_*SSS\_TT*.docx |
| M4 Algorithm | M4\_Algorithm\_*SSS\_TT*.m |
| M4 Regression model | M4\_Regression\_*SSS\_TT*.m |
| M4 Executive Function | M4\_exec\_*SSS\_TT*.m |
| Technical Brief Draft | M4\_TechnicalBrief\_*SSS\_TT*.docx |
| Gradescope Submission | M4\_*SSS\_TT*.pdf |

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

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

## Assignment Header

|  |  |
| --- | --- |
| **Section and Team ID (SSS\_TT):** | <replace this text with your Section\_Team ID> |

|  |  |
| --- | --- |
| **Team Member Name** | **Purdue Career Account Login** |
| Alex Norkus |  |
| Julius Mesa |  |
| Surya Manikhandan |  |
| Vincent Lin |  |

## 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: Summarize the feedback you received on M3 that could lead to improvements in your work.**  <write your response here> |
| **Part B: Explain how you will incorporate the M3 feedback to improve your parameter identification** (do not just reword your response from Part A).  <write your response here> |

## Part 1: Algorithm Refinements Plan

Respond to each of the prompts below in the space provided. Your goal is to introduce **two refinements** to your M3 algorithm, and these refinements must improve your solution to the NovelEnzymes parameter identification problem. Read the rest of this document carefully ***before*** you begin your work on this milestone.

### Definition of “refinement”

In this milestone, a refinement will fall into one of the following categories:

* **Refinement Category 1: Parameter Identification (Required)**

An improvement that changes the way you are doing parameter identification, and that improves your parameter identification results.

* **Refinement Category 2: Algorithm Efficiency**

An improvement that improves the efficiency of your code by (for example) removing un-needed looping structures, streamlining data handling, or otherwise reducing the execution time of your code.

* **Refinement Category 3: Algorithm Insight**

An improvement that involves analysis of your code and its limitations. For example, if you use any kind of thresholding in your code, you could determine the sensitivity of the solution to changes in that threshold parameter, and report how those changes affect your parameter identification and/or regression results.

In this milestone, you are **REQUIRED** to implement **two** refinements. One refinement must be in Category 1. The second refinement can come from either Category 2 or Category 3. Use your ideas from Part 3 of M3 to help formulate ideas. Briefly describe, in words (not code), the nature of the refinements 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.

**Table 2. Algorithm refinement plans**

|  |
| --- |
| **Refinement 1: Category 1. Parameter Identification** |
| **Parameter(s) Targeted:** <*declare parameter(s) here*>  Description  *<insert your answer here>* |
| Rationale for Refinement  *<insert your answer here>* |
| **Refinement 2** |
| Category of Refinement  *<insert your answer here>* |
| Description  *<insert your answer here>* |
| Rationale for Refinement  *<insert your answer here>* |

## 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\_Regression\_*SSS\_TT*.m
* M4\_exec\_*SSS\_TT*.m

### Category 1 Refinement (Required)

Implement your Category 1 refinements in M4\_Algorithm\_*SSS\_tt*.m. Clearly comment the refinement changes within the code, using the text ‘Category 1’ and a concise, meaningful description of the change.

Evaluate the improvement in your algorithm by using the clean and noisy data for the reference enzyme PGO-X50 from M2. Compare the parameters identified for the PGO-X50 data using the algorithm you submitted in M3 and your refined algorithm for M4. Report your results in Table 3. Take care with decimal places.

**Table 3. Algorithm refinement comparison**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter**  **(μM/min)** | **PGO-X50 Reference Values** | | **M3\_Algorithm** | | **M4\_Algorithm** | |
| **Clean** | **Noisy** | **Clean** | **Noisy** | **Clean** | **Noisy** |
|  | 0.028 | 0.028 |  |  |  |  |
|  | 0.056 | 0.055 |  |  |  |  |
|  | 0.110 | 0.11 |  |  |  |  |
|  | 0.193 | 0.19 |  |  |  |  |
|  | 0.360 | 0.338 |  |  |  |  |
|  | 0.6 | 0.613 |  |  |  |  |
|  | 0.883 | 0.917 |  |  |  |  |
|  | 1.212 | 1.201 |  |  |  |  |
|  | 1.376 | 1.282 |  |  |  |  |
|  | 1.584 | 1.57 |  |  |  |  |
|  | 1.72 | 1.61 |  |  |  |  |
| (μM) | 226.92 | 214.28 |  |  |  |  |
| SSE (μM/min)2 | 0.0041 | 0.0251 |  |  |  |  |
| \* Verify your SSE values by comparing them to the provided SSE values for the reference parameters. | | | | | | |

Next, use your M4 algorithm to analyze the full 100 enzyme test data sets and obtain the parameters and . In Table 4, copy your enzyme parameter and model goodness of fit results from M3 (i.e., the values from M3 Table 3) and record your results from your M4 algorithm. Take care with decimal places.

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

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Enzyme** | **M3 Algorithm** | | | **M4 Algorithm** | | |
| **Enzyme Parameters** | | **SSE**  **(μM/s)2** | **Enzyme Parameters** | | **SSE**  **(μM/s)2** |
| **(μM/s)** | **(μM)** | **(μM/s)** | **(μM)** |
| NextGen-A |  |  |  |  |  |  |
| NextGen-B |  |  |  |  |  |  |
| NextGen-C |  |  |  |  |  |  |
| NextGen-D |  |  |  |  |  |  |
| NextGen-E |  |  |  |  |  |  |

### Category 2 Refinement (Optional—Chose one of either Category 2 or 3)

Implement your Category 2 refinements to increase the efficiency of your algorithm. Run your code and document the effect of the refinements. Use the MATLAB functions tic and toc to measure how long it takes your program to execute. Efficiency refinements must be clearly commented in your M4 code with the text ‘Category 2’ and a concise, meaningful description.

**Do not delete** any code as you implement the refinements: comment out unnecessary code and comment on the change. New code must be designated as such.

Record the execution time of your M3 program and your refined M4 program in Table 5.

**Table 5. Program execution times**

|  |  |
| --- | --- |
| **Program** | **Execution Time (s)** |
| M3 (before refinement) |  |
| M4 (after refinement) |  |

### Category 3 Refinement (Optional—Chose one of either Category 2 or 3)

After refining the robustness and performance of your algorithm in light of changes in a thresholding or other variable hardcoded in your algorithm, create one or more plots that illustrate the insights you have gained. The plot(s) should be suitable for technical presentation and clearly illustrate the effect of changes on the parameter identification and/or other results. Write a paragraph that complements the plot(s). This paragraph must clearly describe changes to the thresholding or other variables hardcoded in your algorithm and the insights you gained. The variables used in this analysis must be clearly commented in your code with the text ‘Category 3’ and a concise, meaningful description.

If you need guidance or other suggestions about how to execute this refinement, be sure to ask the teaching team.

**Table 6. Algorithm insight results**

|  |
| --- |
| Refinement 3 Insight Plot(s) |
| *<insert plot(s) here>* |
| Description of Insights Gained |
| <write description here> |

## Part 3: Enzyme Pricing Recommendations

Now that you have implemented your algorithm refinements, you have a set of parameters with which to determine an initial price point for each of the five enzymes. Considering the parameters found by your M4 algorithm, decide what changes, if any, you need to make to your regression algorithm. These could be corrections, response to M3 feedback, or changes to model function. Implement changes as needed.

Report the regression model information in Table 7. Take care with decimal places.

**Table 7. Regression results**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Plot** |
| Model |  |  |
| SSE ($2) |  |
| SST ($2) |  |
| r2 |  |

Using your model, provide a price for each enzyme. Report your values in Table 8. Add an indicator to any extrapolated value.

**Table 8. Price prediction for each enzyme using regression model**

|  |  |
| --- | --- |
| **Enzyme** | **Price ($)** |
| NextGen-A |  |
| NextGen-B |  |
| NextGen-C |  |
| NextGen-D |  |
| NextGen-E |  |

In Table 9, justify your regression function selection and any extrapolation required to provide a using evidence-based rationales.

**Table 9. Regression model justification**

|  |
| --- |
|  |

## Part 4: Technical Brief Draft

Consult the M4 memo from NovelEnzymes, 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.

**Table 10. References used in evidence-based rationales (answer sheet only)**

|  |
| --- |
|  |

## How to Submit

1. Rename this answer sheet to be **Project\_M4\_AnswerSheet\_*SSS*\_*TT*.docx** where ***SSS*** is your section number (e.g., 001 for section 001) and ***TT*** is your team number (e.g., 07 for team 7). Save the answer sheet as a PDF.
2. Create a PDF of your technical brief document.
3. Publish each function you created in this milestone. Note: you may publish sub-functions (such as M4\_Algorithm\_*SSS\_TT*.m) without filling in appropriate inputs or outputs – this will generate an error in the published code for that function that will not affect your grade. Note: these functions must run properly when called by your executive function.
4. Merge the answer sheet PDF, the technical brief PDF, and the published code PDFs into one PDF file named **M4**\_***SSS*\_*TT*.pdf**.
5. Select one person to submit the PDF for the team. That person should
   1. Log into Gradescope and submit **M4\_*SSS\_TT*.pdf** to the **M4** assignment.
   2. Indicate which pages correspond to each part of the milestone.

**Failure to tag the items appropriately will result in your work receiving losing credit.**

* 1. Select all team members for the group assignment.
  2. Double-check that all team members are assigned to the submission.

1. Select one person to submit all m-files, data files, and answer sheet to the **M4 dropbox** on Blackboard.

**Failure to submit your files to Blackboard may result in every team member receiving a zero on this assignment.**

1. Each team member should confirm that they are part of the submission and that all parts of the answer sheet were properly tagged.
2. After submission, distribute the submitted files to all team members*. Ensure all members of the team have copies of the submitted files.*

## Learning Objectives

**Process Awareness (PA)**

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

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.

1. 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.

1. Test prototypes and analyze results to inform comparison of alternative solutions.
2. Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions.
3. Present findings from iterative testing or optimization efforts used to further improve aspect or performance of a solution.
4. 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.

1. 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.

1. 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.
2. Format reference list of used sources that is traceable to original sources (APA or MLA are recommended)

**Engineering Professional Skills**

1. Fully address all parts of assignment by following instructions and completing all work.
2. Use professional written and oral communication.
3. Format plots for technical presentation.

**Programming**

1. Develop code that follows good programming standards.
2. Perform mathematical operations and calculations within MATLAB.
3. Create and use MATLAB scripts and functions.
4. Debug scripts and functions to ensure programs execute properly, perform all required tasks, and produce expected results.

MOD01. Create mathematical models to describe relationships between data.