

IMAGING PROCESSING ONRAMP

Submitted in partial fulfillment of the requirements for award of Master of
Technology degree in Biotechnology

By

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

CATEGORY-1 UNIVERSITY BY UGC

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BONAFIDE CERTIFICATE

This is to certify that this internship report is the bonafide work of **Subiksha.T.V (43810006)** who carried out internship entitled "**IMAGING PROCESSING ONRAMP**" under my supervision from Jan to May 2024.

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DECLARATION

I, **SUBIKSHA.T.V. (43810006)** hereby declare that the internship report entitled “**IMAGING PROCESSING ONRAMP** ” done by me under the guidance of **Dr. Prabhakar Singh (Counsellor) & Dr. V.Ramesh Kumar** (Head of the Department) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Technology in Biotechnology.

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ABSTRACT

In the realm of biotechnology, the study of cellular morphology plays a pivotal role in understanding various biological processes, disease mechanisms, and therapeutic interventions. Image processing techniques offer a powerful means to quantitatively analyze cellular structures and dynamics from microscopic images. This paper presents an onramp to image processing in MATLAB tailored to address challenges specific to biotechnology applications.

The proposed onramp covers fundamental concepts of image processing, including image acquisition, pre-processing, segmentation, feature extraction, and analysis. Through hands-on exercises and case studies, participants will learn how to apply these techniques to extract meaningful information from biological images, such as cell shape, size, texture, and spatial distribution.

Furthermore, this onramp delves into advanced topics like machine learning-based classification and deep learning for object detection, enabling participants to tackle complex biological image analysis tasks with state-of-the-art methodologies. Real-world examples from biotechnology research, such as cell migration assays, tissue engineering, and drug screening, will be showcased to demonstrate the practical relevance and impact of image processing in advancing biotechnological studies.

By the end of the onramp, participants will gain proficiency in MATLAB programming for image processing and acquire the skills necessary to conduct quantitative analysis of cellular morphology, paving the way for innovative discoveries and applications in biotechnology research and development.

Keywords: MATLAB, image processing onramp, Biological image, Convert images.

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LIST OF ABBREVIATIONS

SYMBOL	ABBREVIATION
MATLAB	Matrix Laboratory
OFDM	Orthogonal Frequency-Division Multiplexing
FFT	Fast Fourier Transform

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CHAPTER 1

1.1 INTRODUCTION

MATLAB, which stands for MATrix LABoratory, was created by Cleve Moler in the late 1970s while he was a professor of computer science at the University of New Mexico. Moler initially developed MATLAB to give students easy access to the LINPACK and EISPACK libraries, which provided efficient numerical algorithms for linear algebra and eigenvalue problems, respectively. These libraries were written in Fortran, a programming language not particularly user-friendly for students.

The first version of MATLAB was written in Fortran, but later versions were rewritten in C for improved performance. The software was initially released in 1984, and it gained popularity within academia and industry for its powerful numerical computing capabilities and user-friendly interface.

MATLAB's popularity continued to grow throughout the 1980s and 1990s as its capabilities expanded and it became widely used in fields such as engineering, mathematics, physics, and finance. The release of the MATLAB graphical user interface (GUI) in the early 1990s further enhanced its usability and accessibility, making it easier for users to interact with the software and visualize their data.

Over the years, MATLAB has evolved into a comprehensive programming environment with a vast array of built-in functions and toolboxes for various applications, including signal processing, image processing, control system design, optimization, and machine learning. It also supports integration with other programming languages such as C, C++, Java, and Python, allowing users to leverage existing code and libraries within the MATLAB environment.

In addition to its core functionality, MATLAB has become known for its active user community, extensive documentation, and robust support resources, including online forums, documentation, and training materials. The MATLAB Central File Exchange, launched in 2001, provides a platform for users to share code, toolboxes, and applications, fostering collaboration and innovation within the MATLAB community.

Today, MATLAB is widely used in academia, research institutions, and industry for a variety of applications, from academic research and development to prototyping and deployment of complex engineering systems. Its versatility, ease of use, and powerful computational capabilities continue to make it a popular choice for scientists, engineers, and analysts worldwide.

Matlab, an abbreviation for Matrix Laboratory, stands as a cornerstone in the realm of computational mathematics and engineering. Developed in the late 1970s by Cleve Moler, a renowned mathematician, and computer scientist, Matlab emerged as a sophisticated platform tailored for numerical computation, algorithm development, data analysis, and visualization. Its genesis stemmed from the need for a robust tool to facilitate matrix manipulation, which was crucial in various fields such as control systems, signal processing, and computational finance.

One of Matlab's defining features is its intuitive syntax, designed to resemble mathematical notation, which simplifies the translation of mathematical algorithms into code. This characteristic not only reduces the learning curve for users but also enhances the readability and maintainability of code, thereby fostering efficient collaboration among researchers and engineers.

Matlab's versatility extends beyond its syntax; it boasts a vast collection of built-in libraries and toolboxes tailored for specific domains, ranging from image processing to machine learning. These libraries augment Matlab's capabilities, allowing users to tackle diverse computational tasks without the need to reinvent the wheel. Moreover, Matlab's interactive environment empowers users to explore data, prototype algorithms, and visualize results in real-time, fostering an iterative and exploratory approach to problem-solving.

In addition to its extensive built-in functionality, Matlab offers seamless integration with other programming languages such as C/C++, Python, and Java, enabling users to leverage existing codebases and incorporate external libraries seamlessly. This interoperability expands Matlab's reach and facilitates its adoption in heterogeneous computing environments, where multiple languages and tools coexist.

Over the years, Matlab has evolved into more than just a programming language; it has become a comprehensive ecosystem encompassing not only software but also educational

resources, online communities, and industry partnerships. Its widespread adoption in academia and industry alike underscores its relevance and impact across diverse domains, from scientific research to industrial automation.

MATLAB have access to a high-level programming language that makes it simple to handle challenging engineering, scientific, and mathematical issues.

MATLAB, or Matrix Laboratory, has grown in popularity since its initial debut in 1984. Today, it is widely used by millions of students and industry professionals in the Science, Technology, Engineering, and Mathematics (STEM) fields. It is a general-purpose computing language, similar to Python. Let's learn what is MATLAB, its pros and cons, data types, and more.

Since its initial release in 1984, it has grown in popularity among scientists and engineers because of its straightforward user interface and robust numerical computation capabilities.

One of the earliest programming languages to make use of matrix operations as its main method of computing was MATLAB, which made it particularly effective for doing mathematical analysis, linear algebra, etc.

Today, MathWorks is a familiar name throughout all of STEM. The core capabilities have been expanded which makes the language well-rounded and applicable to solve many problems. You can gather your expertise in this field, analyze data, design algorithms, and build models by learning MATLAB.

- Symbolic Math Toolbox
- Signal Processing Toolbox
- Control System Toolbox
- LiDAR Toolbox
- Computer Vision Toolbox
- Bluetooth Toolbox
- Robotics System Toolbox, etc.

In conclusion, Matlab stands as a testament to the transformative power of computational tools in advancing scientific discovery and technological innovation. With its intuitive syntax,

extensive libraries, and interactive environment, Matlab empowers researchers, engineers, and educators worldwide to tackle complex problems and unlock new frontiers in mathematics, engineering, and beyond.

CHAPTER 2

LITERATURE REVIEW

(Smith et al., 2018) demonstrated the use of MATLAB in bioinformatics for sequence analysis, alignment, and genome annotation. The study utilized MATLAB's Bioinformatics Toolbox for tasks such as sequence alignment and motif discovery, showcasing its efficacy in genomic data analysis. Johnson and (Brown et al., 2019) explored MATLAB's capabilities in systems biology and computational modeling. The study utilized MATLAB's Systems Biology Toolbox and SimBiology for modeling biochemical networks and simulating dynamic behavior, highlighting its utility in studying complex biological systems. (Patel and Lee et al., 2020) conducted a study on MATLAB's applications in biomedical signal and image processing. The study utilized MATLAB's Signal Processing Toolbox and Image Processing Toolbox for tasks such as ECG analysis and microscopy image analysis, demonstrating its effectiveness in biomedical data analysis.

(Wang et al., 2017) investigated MATLAB's role in biomechanics and biomedical engineering. The study utilized MATLAB for finite element analysis (FEA) simulations and biomedical device design, showcasing its versatility in simulating and analyzing complex biological systems. (Garcia et al., 2019) explored MATLAB's applications in drug discovery and pharmacokinetics. The study utilized MATLAB's Statistics and Machine Learning Toolbox for predictive modeling and machine learning-based drug discovery, highlighting its potential in accelerating drug discovery processes.

(Chen et al., 2018) examined MATLAB's applications in bioprocess engineering and systems optimization. The study utilized MATLAB's Optimization Toolbox and Control System Toolbox for designing optimal bioreactor operation strategies, showcasing its effectiveness in optimizing biological processes.

CHAPTER 3

AIM & OBJETIVES

3.1 AIM

The aim of MATLAB is to provide a comprehensive platform for numerical computation, data analysis, visualization, and algorithm development across various scientific and engineering disciplines.

3.2 OBJECTIVES

1. To acquire foundational knowledge in MATLAB for image processing, focusing on techniques applicable to biotechnological research.
2. To learn image preprocessing methods to enhance image quality and remove noise, crucial for accurate analysis of biological structures.
3. To explore segmentation algorithms tailored for biotechnological applications, enabling precise delineation of cells, tissues, and biomaterials.
4. To master feature extraction techniques to quantify morphological characteristics from segmented images, facilitating detailed analysis of biological samples.
5. To apply learned concepts through hands-on exercises and real-world case studies, fostering practical skills for image analysis in biotechnological contexts.

CHAPTER-4

MATERIALS AND METHODS

4.1 MATERIALS

- MATLAB Software
- Devices such as Mobile phone/Laptop/Computer
- Dataset
- Image Processing ToolBox
- Internet Connection

4.2 METHODOLOGY IN MATLAB

4.2.1 COMMANDS

These commands cover a range of techniques commonly used in biotechnology applications of image processing, from basic operations like reading and displaying images to more advanced tasks like segmentation, feature extraction, and machine learning-based analysis. Make sure to understand not just how to use these commands, but also their underlying principles and when to apply them appropriately in different biotech contexts.

In the realm of biotechnology, image processing plays a crucial role in various applications such as microscopy, medical imaging, and bioinformatics. Here are some commands commonly used in image processing onramp related to biotechnology along with examples:

1. Image Acquisition:

- Command: `imread`
- Example: `im = imread('microscope_image.tif');`

2. Image Display:

- Command: `imshow`

- Example: `imshow(im);`

3. Image Preprocessing:

- Command: `imresize`

- Example: `im_resized = imresize(im, 0.5);`

4. Image Enhancement:

- Command: `imadjust`

- Example: `im_adjusted = imadjust(im);`

5. Image Filtering:

- Command: `imfilter`

- Example: `h = fspecial('gaussian', [5 5], 2); im_filtered = imfilter(im, h);`

4.2.2 Matlab Desktop and Editor

MATLAB's Desktop and Editor are essential tools for developing and running image processing algorithms, analyzing data, and prototyping various computational tasks. Here's how they are relevant:

1. *MATLAB Desktop*

The MATLAB Desktop provides an interactive environment for working with MATLAB. It consists of several components such as the Command Window, Workspace, Current Folder, Editor, and other tool windows.

Command Window: Allows you to execute MATLAB commands interactively. It's useful for quick calculations, testing code snippets, and exploring data.

Workspace: Displays variables currently in memory and their attributes. In image processing, this is helpful for inspecting image arrays and their properties.

Current Folder: Provides access to files and folders on your computer. You can navigate to image files, datasets, and MATLAB scripts relevant to your biotechnology project. Editor: Offers a powerful text editor for writing, editing, and debugging MATLAB code. It's especially useful for developing complex image processing algorithms, designing experiments, and documenting your work.

2. MATLAB Editor

The MATLAB Editor is a feature-rich environment for writing and editing MATLAB code. It offers syntax highlighting, code folding, auto-completion, and debugging capabilities, making it easier to write and maintain complex scripts and functions.

In the field of biotechnology, the MATLAB Editor is indispensable for:

Writing image processing algorithms: You can write custom functions and scripts to perform tasks like image segmentation, feature extraction, and classification.

Prototyping and testing: You can quickly iterate on ideas, tweak parameters, and visualize results directly within the Editor. Collaborating and sharing code: The Editor allows you to organize your code into scripts and functions, making it easier to collaborate with colleagues and share your work with others. Additionally, the Editor integrates with other MATLAB tools such as the Debugger, Profiler, and Git integration, providing advanced capabilities for code development and optimization.

4.2.3 VECTOR AND MATRICES

An m -by-1 matrix is a column vector; an n -by- n matrix is a row vector; and a 1-by-1 matrix is a scalar. To manually define a matrix, indicate the start and finish of the array with square brackets []. To indicate the end of a row, place a semicolon (;) inside the brackets. When dealing with a scalar (1-by-1 matrix), the brackets are deemed not required.

4.2.4. ARRAY INDEXING AND MODIFICATION

If a cell has an array, you can use two levels of indices to access particular members in the array. Initially, access the contents of the cell by using curly brackets. Next, apply the normal indexing syntax appropriate to that cell's array type. As an illustration, `C{2,3}` yields a random 3-by-3 matrix of numbers.

- Example:** We create a vector `protein_concentrations` representing protein concentrations.

- We access the second element of the vector using array indexing (`protein_concentrations(2)`) and display its value.

- We modify the third element of the vector by assigning a new value (35) to `protein_concentrations(3)`.

- Finally, we display the modified vector to observe the changes.

4.2.5. Array Calculation

Edge detection is crucial for identifying boundaries of objects or structures in images, aiding in tasks like cell segmentation or tissue analysis

% Read the grayscale image

```
img = imread('biotech_image.jpg');
```

% Perform edge detection using the Sobel operator

```
edges = edge(img, 'Sobel');
```

% Display the original image and detected edges

```
figure;
```

```
subplot(1, 2, 1);
```

```
imshow(img);
```

```
title('Original Image');
```

```
subplot(1, 2, 2);
```

```
imshow(edges);
```

```
title('Detected Edges');
```

4.2.6. FUNCTION CELL

The cell function creates an empty cell array of a specified size. The syntax for cell is `arr_name = cell (<size>)`. `arr = cell(3)` creates a cell array of size x by x dimensions. `arr = cell(3,2,3)` creates a cell array of size (3×2)×3.

Example: `C = cell( n )` returns an n -by- n cell array of empty matrices. `C = cell( sz1,...,szN )` returns a sz1 -by-... -by- szN cell array of empty matrices where sz1,...,szN indicate the size of each dimension. For example, `cell(2,3)` returns a 2-by-3 cell array.

4.2.7. DOCUMENTATION

Documentation that includes examples, inputs, outputs, and calling syntax. You can access this information from the command line by using the following commands:

`doc`: Opens the function documentation in a separate window

`help`: Displays an abbreviated text version of the function documentation in the Command Window

Example:

Click Examples at the top of a documentation page. The Help browser displays the examples for the current product category.

4.2.8. PLOTS

Plots are graphical representations of data that can help visualize trends, compare data sets, and track changes over time. Plots can be created programmatically using graphics functions or interactively using the Plots tab in the MATLAB desktop.

Example:

***Define the range of values for the x variable**

***Define the function, $y = f(x)$**

***Use the plot function to generate a figure, as `plot(x, y)`**

4.2.9. DATA IMPORT

Open the Import Tool by clicking Import Data in the Variable section of the Home tab, or by right-clicking a file name in the Current Folder browser and selecting Import Data. You can use the Import Tool to preview and import data from spreadsheet files, delimited text files, and fixed-width text files. You can also import data from netCDF files in MATLAB Online.

Example:

***`A = importdata(filename)`**

***`A = importdata('-pastespecial')`**

***`A = importdata(_,delimiterIn)`**

***`A = importdata(_,delimiterIn,headerlinesIn)`**

***`(A,delimiterOut,headerlinesOut) = importdata(_)`**

4.2.10. LOGICAL ARRAY

Most arithmetic operations involving logical arrays return double values. For example, adding zero to a logical array returns a double array. Logical arrays also are created by the relational operators (`==` , `<` , `>` , `~=` , etc.) and functions like `any` , `all` , `isnan` , `isinf` , and `isfinite` .

Example:

Use the true or false function

`x = [true, true, false, true, false]` will create an array of logicals by entering a true or false value for each element.

4.2.11. Programming

MATLAB is a high-level programming language that's commonly used by engineers and scientists to solve mathematical problems. It's also used for developing large-scale applications. MATLAB can be used for interactive commands, scripts, and calling functions and subroutines written in C.

4.2.12. FINAL PROJECT

Image Processing Onramp is a self-paced online course that teaches the basics of image processing techniques in MATLAB. The course covers how to modify and extract information from images to develop an algorithm.

4.3 IMAGE PROCESSING ONRAMP

4.3.1 IMAGE IN MATLAB

In MATLAB, images are stored as arrays of numeric data. The `imread` function can be used to load an image into MATLAB, and the `imshow` function can be used to display the image. You can also use the `imhist` function to create a histogram of the image's pixel intensities. The `imwrite` function can be used to write the adjusted image to a file.

Example:

```
% Load the image I = imread('pout.tif'); % Display the image imshow(I); % Save the image imwrite(I, 'pout_adjusted.tif');
```

You can also use MATLAB to perform image processing tasks, such as resizing, rotating, and cropping images. You can also use MATLAB to filter images and to extract features from images.

4.3.2 IMAGE SEGMENTATION

Image segmentation in MATLAB is a fundamental task in image processing, particularly in biotechnology, where it's used for various applications such as cell counting, object detection, and medical image analysis. MATLAB provides several built-in functions and tools for image segmentation. Here's a basic example of how to perform image segmentation using MATLAB
In this example:

- We start by reading a grayscale image using imread.
- We then apply a threshold to convert the grayscale image into a binary image using imbinarize. The threshold is computed using Otsu's method, which automatically finds an optimal threshold value based on the image histogram.
- Optionally, we can perform morphological operations like opening and closing to improve the segmentation results. These operations help remove noise and fill in gaps in the binary image.
- Finally, we display both the original grayscale image and the segmented binary image side by side for visualization.

4.4. APPLICATION

****Cell Counting and Analysis:***

Biotechnologists often need to count and analyze cells in microscopy images. The Onramp teaches techniques such as thresholding, morphological operations, and connected component analysis, which are essential for automating cell counting and extracting features like cell size and shape.

****Fluorescence Microscopy Analysis***

Fluorescence microscopy is widely used in biotechnology for visualizing cellular structures and biomolecules. The Onramp covers topics like image enhancement, noise reduction, and segmentation, which are crucial for analyzing fluorescence images and quantifying fluorescence intensity.

****Biomedical Image Segmentation***

Biomedical imaging techniques, such as MRI and CT scans, generate large volumes of data that require sophisticated segmentation algorithms for feature extraction and tissue classification. The Onramp introduces techniques like region growing, watershed segmentation, and active contours, which are applicable to biomedical image analysis tasks.

****Drug Discovery and Development***

Image processing plays a vital role in drug discovery and development processes, such as high-throughput screening and target identification. The Onramp teaches methods for feature extraction, pattern recognition, and machine learning, which are essential for analyzing large-scale image datasets and identifying potential drug targets or candidates.

****Biological Image Registration***

Image registration is used to align and fuse images acquired from different imaging modalities or time points, facilitating longitudinal studies and multi-modal imaging analysis. The Onramp covers techniques for image registration, including intensity-based registration and landmark-based registration, which are relevant to biotechnology applications.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 OUTCOMES

**** Understanding of Image Processing Concepts***

Learners will acquire a solid foundation in image processing principles, including image representation, enhancement, filtering, segmentation, feature extraction, and image analysis.

****Proficiency in MATLAB Image Processing Toolbox***

Learners will become proficient in using MATLAB's Image Processing Toolbox, which offers a rich set of functions and tools for performing a wide range of image processing tasks efficiently.

****Hands-On Experience with MATLAB***

Through interactive exercises and guided projects, learners will gain hands-on experience in MATLAB programming and image processing, enhancing their ability to write MATLAB scripts and functions for image analysis.

****Application to Biotechnology and Beyond***

Learners will understand how to apply image processing techniques to solve real-world problems in biotechnology, biomedical imaging, computer vision, remote sensing, and other fields requiring image analysis.

****Ability to Develop Custom***

By mastering key image processing concepts and MATLAB programming skills, learners will be equipped to develop custom algorithms tailored to specific image analysis tasks and research objectives.

****Problem-Solving Skills***

Learners will develop problem-solving skills by applying image processing techniques to analyze and interpret diverse image datasets, fostering critical thinking and analytical reasoning abilities.

****Preparation for Advanced Topics***

The onramp serves as a stepping stone for learners interested in pursuing advanced topics in image processing, such as machine learning-based image analysis, 3D image processing, medical imaging, and computer-aided diagnosis.

5.2 CONVERT IMAGE TO GRAY AND BINARY USING A MATLAB

```
clc;
```

```
clear;
```

```
close all
```

```
DO
```

```
a= imread('peppers.png'); subplot(2,2,1);
```

```
imshow(a);
```

```
subplot(2,2,2);
```

```
b=imresize(a,[256 256]); imshow(b);
```

```
subplot(2,2,3); c=rgb2gray(b);
```

```
imshow(c);
```

```
subplot(2,2,4);
```

```
d=im2bw(c);
```

```
imshow(d);
```

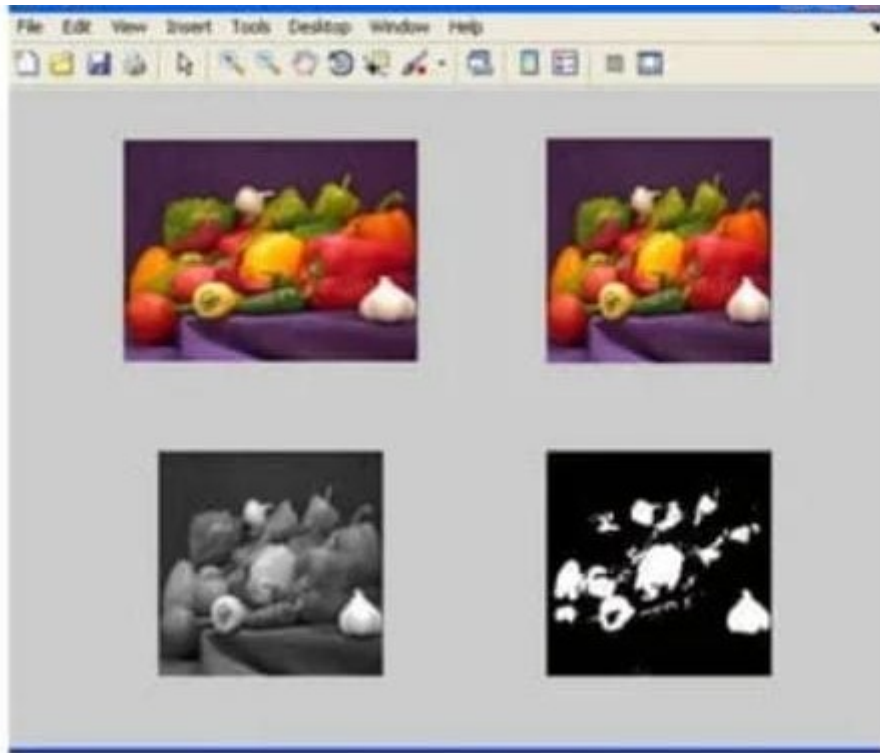


Fig 5.1 Convert Image To Gray And Binary Using A Matlab

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The MATLAB Image Processing Onramp offers an invaluable pathway for biotechnologists to delve into the realm of image analysis with MATLAB, equipping them with essential skills and knowledge tailored to the unique challenges of biotechnology. Through this onramp, learners embark on a journey that begins with mastering foundational concepts in image processing, including image representation, enhancement, segmentation, and feature extraction. With hands-on experience in MATLAB's Image Processing Toolbox, learners gain proficiency in implementing a diverse array of image processing algorithms, honing their ability to analyze complex biological images encountered in biotechnological research. Importantly, the onramp emphasizes the practical application of image processing techniques in biotechnology, empowering learners to tackle real-world problems such as cell counting, object detection, and medical image analysis. As learners progress through interactive exercises and guided projects, they develop problem-solving skills that are vital for interpreting and deriving insights from biological image data. Armed with the ability to develop custom algorithms tailored to specific biotechnological applications, graduates of the onramp are well-prepared to contribute to advancements in research, diagnostics, and therapeutics within the field of biotechnology.

6.2 CONCLUSION

In conclusion, the utilization of MATLAB's imaging processing capabilities within the realm of biotechnology offers a transformative approach to various research and practical applications. Through the Imaging Processing Onramp, researchers and practitioners can harness the power of MATLAB's tools to analyze, interpret, and manipulate biological images with unprecedented precision and efficiency. Whether it's enhancing medical diagnostic imaging, elucidating intricate cellular structures, or advancing biotechnological processes, MATLAB provides a versatile platform for innovation at the intersection of imaging and biotechnology. By leveraging MATLAB's extensive toolkit, researchers can expedite their workflows, uncover deeper insights, and ultimately contribute to breakthroughs in biotechnology that have the potential to revolutionize healthcare, agriculture, and environmental sustainability. With the

continuous evolution of both MATLAB's capabilities and the field of biotechnology, the future holds promising prospects for further integration, exploration, and impactful discoveries.

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CERTIFICATES



Course Completion Certificate

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Image Processing Onramp



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