



ENVIRONMENT MODELING USING MATLAB

ABSTRACT

The aim of project is to combine the attributes of MATLAB and detail design procedures related to environmental system. Environmental modeling is a science that uses mathematics and computers to simulate physical, chemical, biological phenomena in the environment. Here, MATLAB is used for developing environmental model. The methodology includes steps of relating input and output variables, forming algorithms, developing flowcharts, writing the code and then testing it to remove any error.

Environmental modeling is a science that uses mathematics and computers to simulate physical and chemical phenomena in the environment (e.g., environmental pollution). This science was initially based on pen-and-paper calculations using simple equations. In the last 50 years, with the development of digital computers, environmental models have become more and more complex, requiring often numerical solutions for systems of partial differential equations.

The description of processes is translated into mathematical terms. Often the approach leads to differential equations, which are conditions concerning the change of a variable, like concentration or population density, in space and time. Nowadays the solution of such equations is not as tedious as in former times.

It is not the aim of modeling to set up complex models representing different environmental systems. The opposite of that statement is a more suitable goal: the aim of modeling is to find simple models that explain some aspects of a real system. Unfortunately that aim turns out to be a tricky one, because every real system appears to be complex, as long as there is ample knowledge about the driving mechanisms. Moreover, if a system is complex, a simple model can explain a few aspects at the most and that may not.

There are various types of models in the environmental sciences. It may also correlate with other branches of sciences such as chemistry, physics, microbiology, geology, and hydrology. There are a number of applications of engineering studies for finding out proper solutions related the environmental system. Various mathematical tools are also implemented for the accurate result. A model may be developed representing flow pattern of river, variation occurred due to contamination. Self purification capacity of river is also determined

by developing a model for individual environment sink. A model may also be developed for determining level of toxicity released by varying group of industries such as textile, pharmaceutical, petroleum, metal, dye-intermediates for a particular range of area. Another model may also be developed for identifying the dispersion characteristics of various particulates present into the atmosphere. Model may also include the survival pattern of different species and represent predefined characteristics of a specific group of species.

CONCEPT OF DESIGN

The concept of design may be explained as a reactor which converts raw material (here, consider design input) into final product (consider, design output). To perform this reaction, the equipment must have facilities of yielding out the final desired product. Here, reactor refers to the program developed to perform appropriate calculations. This program, in return, brings out the output data for specific value of inputs.

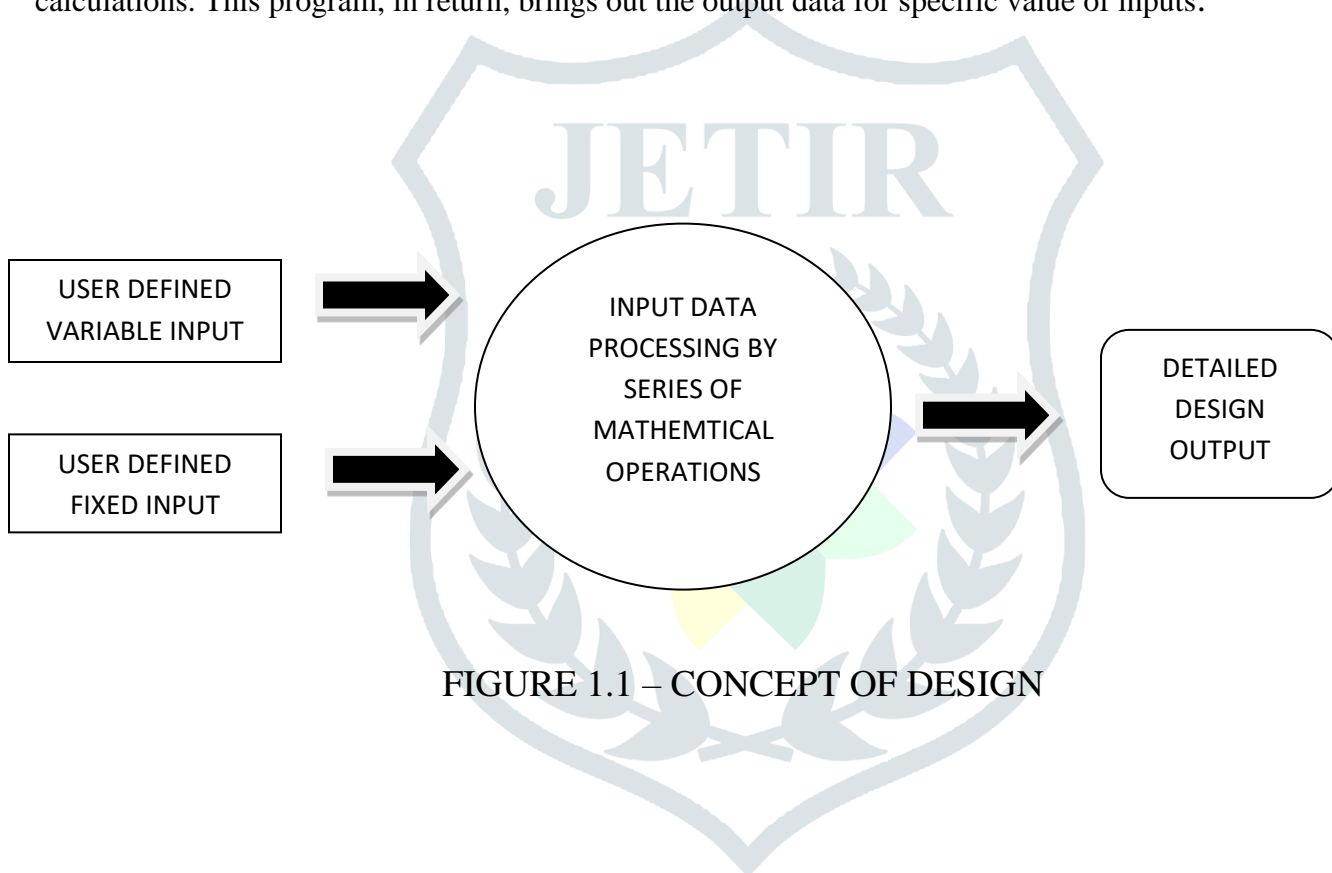


FIGURE 1.1 – CONCEPT OF DESIGN

STAGES OF DESIGN PROCESS

- INPUT AND OUTPUT VARIABLE
- DEFINING SERIES OF MATHEMATICAL OPERATIONS
- DEVELOPING ALGORITHM
- WRITING PROGRAM CODE
- OPTIMIZATION & ITERATION
- TESTING
- DEBUGGING
- IMPROVEMENT

For basic information a simple environment model is illustrated later part of the study.

A Simple Environmental Model

As an introductory simple situation consider the population of a biological species, which is denoted by c . As a first approach it seems reasonable that the number of children increases with the population itself. The number of children stands for the reproduction rate of the species, denoted as $\delta c / \delta t$, the temporal change of the population at each time instant. For the sake of simplicity one may consider that the reproduction rate is proportional to c :

$$\frac{\partial c}{\partial t} \propto c$$

When the proportionality factor is denoted by α , the same relation is expressed by the equation

$$\frac{\partial c}{\partial t} = \alpha c$$

which is a differential equation for the population c as a function of time t . With this equation the first task in modeling is already performed. The conceptual model, the proportionality relationship, is expressed as a differential equation.

In general, the detailed design procedure consists of mathematical operations on input data such as particle density, viscosity of gas stream, inlet velocity of particulate laden gas stream and computing output data such as area required, dimension of equipments, diameter of the equipment etc.

MATLAB as Computational and Modelling Tool

MATLAB is a numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB stands for MATRIX LABORATORY. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran.

MATLAB can be used for a range of applications, including signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. In 2004, MATLAB had around one million users across industry and academia. MATLAB users come from various backgrounds of engineering, science, and economics. MATLAB is widely used in academic and research institutions as well as industrial enterprises.

INTERFACING WITH OTHER LANGUAGES

MATLAB can call functions and subroutines written in the C programming language or FORTTRAN. A wrapper function is created allowing MATLAB data types to be passed and returned. The dynamically loadable object files created by compiling such functions are termed "MEX-files" (for MATLABexecutable).

Libraries written in Perl, Java, ActiveX or .NET can be directly called from MATLAB, and many MATLAB libraries (for example XML or SQL support) are implemented as wrappers around Java or ActiveX libraries. Calling MATLAB from Java is more complicated, but can be done with a MATLAB toolbox which is sold separately by MathWorks, or using an undocumented mechanism called JMI (Java-to-MATLAB Interface), (which should not be confused with the unrelated Java Metadata Interface that is also called JMI).

As alternatives to the MuPAD based Symbolic Math Toolbox available from MathWorks, MATLAB can be connected to Maple or Mathematica.

Libraries also exist to import and export MathML.

LICENSE

MATLAB is a proprietary product of MathWorks, so users are subject to vendor lock-in. Although MATLAB Builder product can deploy MATLAB functions as library files which can be used with .NET or Java application building environment, future development will still be tied to the MATLAB language.

Each toolbox is purchased separately. If an evaluation license is requested, the MathWorks sales department requires detailed information about the project for which MATLAB is to be evaluated. Overall the process of acquiring a license is expensive in terms of money and time. If granted (which it often is), the evaluation license is valid for two to four weeks. A student version of MATLAB is also available.

It has been reported that EU competition regulators are investigating whether MathWorks refused to sell licenses to a competitor.

ALTERNATIVES

MATLAB has a number of competitors. Commercial competitors include Mathematica, Maple, and IDL. There are also free open source alternatives to MATLAB, in particular GNU Octave, FreeMat, and Scilab which are intended to be mostly compatible with the MATLAB language. Among other languages that treat arrays as basic entities (array programming languages) are APL, Fortran 90 and higher, S-Lang, as well as the statistical languages R and S. There are also libraries to add similar functionality to existing languages, such as IT++ for C++, Perl Data Language for Perl, and SciPy for Python.

GNU Octave stands out as it treats incompatibility with MATLAB as a bug (see GNU Octave#Matlab), therefore it aims to provide a software clone.

FILE EXTENSIONS

In MATLAB, there are different files available for different purposes. Each file has its unique extension. A simple M-file is having .m extension, while a file containing figure possesses the extension of '.fig'. Some of these extensions are presented in the table below.

Extensions	Stands For
.fig	MATLAB figure
.m	MATLAB code
.mat	MATLAB data
.mex (.mexw32, .mexw64, .mexglx, ...)	MATLAB executable MEX-files(platform specific eg. “mexmac” for the Mac, “.mexglx” for Linux, etc.)
.p	MATLAB content-obscured .m file
.mlappinstall	Packaged App Installer

Table 4.2 – File Extensions

KEY FEATURES

- High-level language for numerical computation, visualization, and application development
- Interactive environment for iterative exploration, design, and problem solving
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration, and solving ordinary differential equations.
- Built-in graphics for visualizing data and tools for creating custom plots.
- Development tools for improving code quality and maintainability and maximizing performance.
- Tools for building applications with custom graphical interfaces
- Functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET, and Microsoft Excel.

ADVANTAGES

MATLAB has many advantages compared with conventional computer languages for technical problem solving. These include

- Ease of Use
- Platform
- Independence
- Predefined Functions
- Device-Independent Plotting
- Graphical User Interface
- MATLAB Compiler

DISADVANTAGES

MATLAB has two principal disadvantages. The first is that it is an interpreted language and therefore may execute more slowly than compiled languages. This problem can be mitigated by properly structuring the MATLAB program.

The second disadvantage is cost: a full copy of MATLAB is five to ten times more expensive than a conventional C or FORTRAN compiler. This relatively high cost is more than offset by the reduced time required for an engineer or scientist to create a working program, so MATLAB is cost-effective for businesses. However, it is too expensive for most individuals to consider purchasing. Fortunately, there is also an inexpensive Student Edition of MATLAB, which is a great tool for students wishing to learn the language. The Student Edition of MATLAB is essentially identical to the full edition.

Programming with MATLAB

There are two kinds of program files:

- Scripts, which do not accept input arguments or return output arguments. They operate on data in the workspace.
- Functions, which can accept input arguments and return output arguments. Internal variables are local to the function.

Function Files

Functions are M-files that can accept input arguments and return output arguments. The names of the M-file and of the function should be the same. Functions operate on variables within their own workspace, separate from the workspace you access at the MATLAB command prompt.

Anatomy of an M-function file

This simple function shows the basic parts of an M file.

```
function f = factorial(n)      (1)
% FACTORIAL(N) returns the factorial of N (2)
% Compute a factorial value. (3)
f = prod(1:n);              (4)
```

The first line of a function M file starts with the keyword `function`. It gives the function *name* and order of *arguments*. In the case of function `factorial`, there are up to one output argument and one input argument.

As an example, for $n = 5$, the result is,

```
>> f = factorial (5)
f =120
```

Part no.	M file element	Descriptio
(1)	Function	The function name, and the definition number and order of input and line output arguments
(2)	H1 line	Define a one line summary description of the program, displayed when you request
(3)	Help text	A more detailed description of the program
(4)	Function body	Program code that performs the actual computations

Table 4.3 – Anatomy of function file

Both functions and scripts can have all of these parts, except for the function definition line which applies to function only.

In addition, it is important to note that *function name* must begin with a letter, and must be no longer than the maximum of 63 characters. Furthermore, the name of the text file that you save will consist of the function name with the extension .m. Thus, the above example file would be factorial.m.

FUNCTION CALLING

MATLAB has a programming language which allows creation of distinct function files and then calling them in a separate m file. This allows user to create a program which takes input, processes the input by the functions written outside its code and produce the output. This becomes advantageous in case of modifying one or more functions involved. Calling of function enables easy modification of individual function file instead of laborious modification of a whole program code.

Illustration of few PROGRAM CODES

Below are few codes given in written form representing various problems.

1. The first program showed here gives prior information of MATLAB program code. This correlates the utilization rate of coal and available reserves itself

```
c0=input(' Enter the value of initial reserves :');
a=input(' Enter the value of years of estimates :');
s=input(' Enter the value of span of years :');
t=[0:s:a];
c=c0*exp(-lambda*t);
plot(t,c);
grid;
```

2. The use of this software also expands as it can be implemented to determination of value of certain parameter. This feature makes MATLAB useful for analytical process.

```
A=input('The reading of sample is :');
B=input('The blank reading is :');
y=input('ml of sample');
disp('in mg/l');
x=((A-B)*0.0141*1000*35.45)/y;
disp(x);
disp('in mg/l');
if(x<100)
    disp('The chloride content is in permissible limit');
else
    disp('the chloride contents is not in permissible limit');
end
```

3. This is the heart of the project. It stands for the design considerations of cyclone separators. By performing this program, the essential diameter required for obtaining desired efficiency can be easily achieved without doing rigorous calculations.

```
viscosity=input('Enter value of viscosity of the fluid to be used : ');
B=input('Enter width of cyclone inlet : ');
v=input('Enter value of average inlet velocity : ');
Nt=input('Enter number of turns made by gas stream in cyclone : ');
densityP=input('Enter the value of density of particulates : ');
density=input('Enter value of density of gas stream : ');
pi=3.14;
Dp=(9*viscosity*B)/(pi*v*Nt*(densityP-density));
disp(Dp);
```

CONCLUSION

This project stands to correlate the applicability of software in the environmental sector. It provides wide range of benefits such as academic purpose, designing purpose and determining adequacy of equipments.

The project emphasized the program codes in simple M-script file for Air pollution control equipment such as cyclone separator and settling chamber giving quick, efficient, precise results with rich user interface & graphical representation for analysis and understanding.

This project is mainly helpful to understand design procedures of control equipments using MATLAB. However, the project with further modifications can become powerful tool in designing procedures due to its ease of implementation and broader range of applications.

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❖ WEB LINKS

- I. <http://www.mathworks.com/support/>
- II. <http://www.mathworks.com/support/books/index.jsp>
- III. <http://www.engineering.dartmouth.edu>.