LEAST-SQUARES PARAMETER ESTIMATION AND ITS APPLICATION IN ELECTRONIC PRODUCTS

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Date : 30th April 2010

Dedicated to my beloved family

To my father and mother

To my respected lecturer/supervisor

And to all my coursemates

For their support, advice, patience and understanding.

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ABSTRACT

This report will present the use of Least-Squares method in Electronic Product such as Integrated Circuit (IC) that manufactured by semiconductor industry. In every production process in industries, there always have reject items in production line. There are many methods to solve this problem in industries but currently the industry need an alternative and simple method to solve this problem in order to improve their previous statistical analysis method. The objective of least-squares method is to help industrial engineers to predict their output of product based on the mathematical model that have been developed in this project. In order to achieve the objective of this project, several sample data is collected from the semiconductor industries to develop a reliable linear mathematical model. This model can be applied to predict the future output based on any kind of input data collected from production. This report will begin with a general introduction the project including the problem statements and objectives then moving on to the understanding of linear least-squares method and the development of mathematical model. Besides that, the development of graphical user interface (GUI) software by using Visual Basic Program will be discussed as well. Finally, suggestions for future implementations will be included.

ABSTRAK

Report ini akan menjelaskan kegunaan kaedah *Least-Squares* dalam produk elektronik seperti litar bersepadu (IC) yang dihasilkan oleh industri semikonduktor. Dalam proses penghasilan sesuatu produk dalam industri, terdapat unit yang rosak atau ditolak oleh industri. Terdapat pelbagai kaedah untuk menyelesaikan masalah ini dalam industri tetapi industri kini memerlukan kaedah alternatif dan mudah untuk menyelesaikan masalah mereka sebagai langkah untuk memperbaik kaedah analisis statistik yang sedia ada. Tujuan bagi keadah *least-squares* ini adalah untuk membantu jurutera industri dalam meramalkan hasil keluaran produk mereka berdasarkan model matematik yang telah dihasilkan dalam projek ini. Untuk mencapai matlamat projek ini, beberapa contoh data telah dikumpul daripada industri semikonduktor untuk menghasilkan model matematik yang boleh dipercayai. Model ini boleh digunakan untuk meramalkan hasil keluaran produk yang akan datang bergantung pada jenis input data yang dikumpulkan. Laporan ini akan bermula dengan pengenalan umum projek termasuk pernyataan masalah dan objektif dan juga pemahaman tentang kaedah *linear least-squares* dan penghasilan model matematik. Di samping itu, penghasilan perisian bagi pengguna (GUI) dengan menggunakan program *Visual Basic* akan termasuk dalam bab juga. Akhirnya, cadangan untuk implementasi masa depan akan disertakan.

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LIST OF ABBREVIATIONS

VB	-	Visual Basic
IDE	-	Integrated Development Environment
e	-	Error
SS	-	Sum of Squares
df	-	Degree of freedom
GUI	-	Graphical User Interface

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Least-Squares is basically, a method of estimating parameters in a model by minimizing the sum of squares of differences between observed and theoretical values of a variable [4]. The least-squares method can be applied in making adjustment and comparison of observations. The adjustment of observation is necessary when several precise measurements are made, even upon the same quantity under apparently similar conditions, the results do not agree. The comparison of observations is necessary in order to determine the relative degrees of precision of different sets of measurements made under different circumstances either for the purpose of properly combining and adjusting it or to ascertain the best methods of observation.

1.2 OBJECTIVES

The objectives of this project are:

1. To develop mathematical model, analyze and tests its performance.
2. To propose an action plan to optimize the number of items produced.
3. To produce friendly software in this problem by using Visual Basic.

1.3 SCOPE OF WORK

The scopes of works in this project are:

1.3.1 To develop mathematical model based on daily production in factory

The mathematical model such as y = ax+b will be build in this project. The model is depends on the daily production data.

1.3.2 Numbers of machine that produce the product in the factory are limited

The machine used in the factory consists of only 10 machines which running the same function.

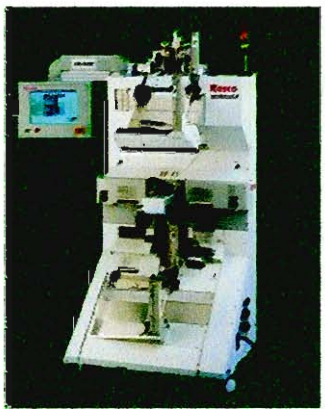

Figure 1.3: Example of one type machine

1.3.3 Types of least-squares method

In this project, the linear least-squares method will be cover.

1.3.4 Parameters of least-squares

The unknown parameter use in this project are a and b respectively. Both of this parameter will be applied in linear least-squares method.

1.3.5 Data collection for analysis

The data required in this project will be collected from a factory. The data are collected from the same types of machine at certain range of time. It is about the daily production of the factory.

1.3.6 Software Development

A user friendly software will be develop through this project to enable the user to key in data for statistic analysis by using graphical user interface (GUI) in Visual Basic Language.

CHAPTER II

LITERATURE REVIEW

2.1 LITERATURE REVIEW

2.1.1 Linear least-squares

Linear least squares is a computational approach to fitting a mathematical or statistical model to data [6]. It can be applied when the idealized value provided by the model for each data point is expressed linearly in terms of the unknown parameters of the model [7]. The resulting fitted model can be used to summarize the data, to predict unobserved values from the same system, and to understand the mechanisms that may underlie the system.

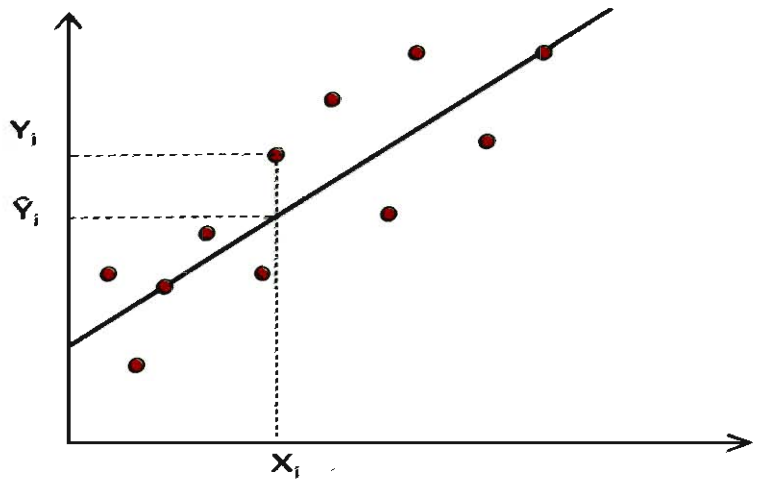

Figure 2.1: Linear least-squares graph

Linear least squares is one type of regression analysis where the best approximation is defined as that which minimizes the sum of squared differences between the data values and their corresponding modeled values [6]. The approach is called "linear" least squares since the solution depends linearly on the data. Linear least squares regression also gets its name from the way the estimates of the unknown parameters are computed.

Linear least squares regression has earned its place as the primary tool for process modeling because of its effectiveness and completeness. Though there are types of data that are better described by functions that are nonlinear in the parameters, many processes in science and engineering are well-described by linear models. This is because either the processes are inherently linear or because, over short ranges, any process can be well-approximated by a linear model [8].

The estimates of the unknown parameters obtained from linear least squares regression are the optimal estimates from a broad class of possible parameter estimates under the usual assumptions used for process modeling. Good results can be obtained with relatively small data sets [8]. The theory associated with linear regression is well-understood and allows for construction of different types of easily-interpretable statistical intervals for predictions, calibrations, and optimizations. These statistical intervals can then be used to give clear answers to scientific and engineering questions.

2.1.2 Mathematical Model

A mathematical model uses mathematical language to describe a system. Mathematical models are used not only in the natural sciences and engineering disciplines but also in the social sciences [11]. Physicists, engineers, computer scientists, and economists use mathematical models most extensively. The term 'mathematical modeling' means the process of developing a mathematical model. Models describe our beliefs about how the world functions. This has many advantages such as:

1. Mathematics is a very precise language. This helps us to formulate ideas and identify underlying assumptions.
2. Mathematics is a concise language, with well-defined rules for manipulations.
3. All the results that mathematicians have proved over hundreds of years are at our disposal.
4. Computers can be used to perform numerical calculations.

Mathematical modeling can be used for a number of different reasons. How well any particular objective is achieved depends on both the state of knowledge about a system and how well the modeling is done. Examples of the range of objectives are:

- Developing scientific understanding
- Test the effect of changes in a system
- aid decision making

There are many forms of mathematical model. This includes statistical models, dynamical systems, differential equations or others. The simple examples of mathematical model that frequently apply in engineering filed are $y = mx + c$, $V = IR$ and so on. The mathematical model often use by engineers to analyze a system to be controlled or optimized. In analysis, engineers can build a descriptive

model of the system as a hypothesis of how the system could work, or try to estimate how an unforeseeable event could affect the system. Similarly, in control of a system, engineers can try out different control approaches in simulations [11].

A mathematical model usually describes a system by a set of variables and a set of equations that establish relationships between the variables which represent some properties of the system [2]. The actual model is the set of functions that describe the relations between the different variables. On the other hands, when studying models, it is helpful to identify broad categories of models. Classification of individual models into these categories tells us immediately some of the essentials of their structure [2]. One division between models is based on the type of outcome they predict. Deterministic models ignore random variation, and so always predict the same outcome from a given starting point. Meanwhile, the model may be more statistical in nature and so may predict the distribution of possible outcomes. Such models are said to be stochastic.

A second method of distinguishing between types of models is to consider the level of understanding on which the model is based. One further type of model, the system model, is worthy of mention. This is built from a series of sub-models, each of which describes the essence of some interacting components [2]. Much of the modeling literature refers to 'simulation models'. The reason for this apparent omission is that 'simulation' refers to the way the model calculations are done by computer simulation [2]. The actual model of the system is not changed by the way in which the necessary mathematics is performed, although our interpretation of the model may depend on the numerical accuracy of any approximations.

2.1.3 Visual Basic.NET

Visual Basic was first released by Microsoft in the early 1990s. At that time, Visual Basic Version 1 (VB1) was a revolutionary product that introduced a new style of computer programming to the world. Visual Basic was introduced as the savior of Windows, making it possible to create programs that reacted to user

interactions in a way that was natural for the programmer to incorporate. Two key elements gave Visual Basic its power and ease of adoption: the 'Visual' element of the language, which allowed a programmer to design a user-interface by drawing its appearance on the computer screen and configure it interactively, and a new model of programming which allowed the programmer to write 'scripts', or mini-programs that were activated as a response to the user interacting with the user-interface.

Over several versions, Visual Basic gradually grew in power and popularity to become the world's most widely used programming system. It also became Microsoft's standard scripting language for its range of office products, its web browser and servers and a number of third party products such as AutoCAD. By the release of VB6 a few years ago, it was possible to do almost anything in Visual Basic that Microsoft programmers would normally use Visual C++ (Microsoft's industrial strength programming language) for, and in most situations, Visual Basic was far easier to work with and led to quicker development timescales.

However, Visual Basic has always had its detractors. It was a derivation of BASIC, an early programming language (circa 1963) developed in Dartmouth Naval College in the U.S. to teach programming. As such, it lacked the powerful numerical processing capabilities of FORTRAN, and the powerful data storage, retrieval and manipulation capabilities of COBOL. The development of Pascal and the C programming language in the late 1960s and their widespread adoption in the 1970s led to a new model of programming, known as structured programming. Structured programming features were retro-fitted to BASIC and other languages over the next few years, but not before C and Pascal became the de-facto programming languages for systems development.