Designing and Simulating Chopping Process using Workspace5

Zuraini Sukimin, Habibollah Haron
Department of Modeling and Industrial Computing
Faculty of Computer Science & Information Systems
University Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia
fibonancci@yahoo.com, habib@utm.my

Abstract

Simulation and visualization have been developed for the ease of the chopping process. This project is chosen based on the analysis that had been done at the organization where the work of chopped product is done manually using human workforce. The problem that happened here is human workforce will easily get tired and bored with the repeating work. Measurement of the product is also conducted manually. Therefore, the productivity is affected due the manual measurement. The project objective is to overcome the problems by designing and simulating a Cartesian robot to perform the chopping task. The result from the simulation shows that the chopping process can be perform effectively and give accurate measurement of the product. In simulating the proposed Cartesian robot, it is suitable with the chopping process. The software used in this project is Workspace5.

Keywords: *Robotic Simulation, Visualization, Robotic Designing, Workspace5*

1. Introduction

Simulation is a modeling approach which attempts to imitate the dynamic operations of a real world system [1]. It is also considered as a technique that is always being used in modeling a complex problem situation. Development of real system is expensive, fragile and requires careful maintenance [2]. Habitually, simulation has been chosen based on a few reasons such as its complexity, cost and site risk. Besides, the reason why simulation is being used because simulation gives a perfect result which is nearly to the real life. Using simulation visual output helps the end user and assists in model development [1]. Efficacy of model simulation is able to be detected by comparing both model parameters (current model and planning model) such as time produced, cost for each unit, quantity and its lucrative.

Robotic simulation covers the visualization of how the robot moves through its environment [3]. This chopping process is modeled in animation mode, where each movement captures the real life situation and real scale. With this animation mode, an assorted tragedy and bad impact can be dodged and each operation by the robot can be done by experiment to the system. Knowable that, from this simulation the effectiveness of its operation to the specific task is functional.

The main focus in this development of design, visualize and simulate of automation process is to test whether robot usefulness in cutting product can increase the production of manufacture, facilitate the cutting task and cutting speed, accurate scale and free from error for each piece cut off. As the simulation model is running, the cycle time tells the equivalent time would be in the real system and the simulations cycle life runs much faster than it does in real life, to enable the user to see quickly what will happen in the situation being modeled [1]. Robot cycle time must be shorter than the rate of real system [4].

This paper is divided into five sections. Section 2 presents the chopping process, section 3 discuss the methodology for the robot design development and simulation. Simulation and testing result are presented in section 4 and conclusions are drawn in section 5.

2. The chopping process

This project is chosen based on the analysis at the organization where the task of chopping product is done manually using human workforce. As the information from the company is confidential, few data cannot be shown and detail operations are explained briefly.

This section presents the manual operation and its application of the current system. Workforce as the main focus and the flow of the process are stated on Figure 1. The process focuses on cutting dough application.

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The problem that happen in the process, human workforce will become easily tired and bored with the work specification is done. Measurement of the product is also done with manually will result a huge impact on production because the demand for market exceeds everyday's production.

Since the main focuses is chopping the dough, an important element that really close to this process is cycle time per each of chopping process, choppingsize and quantity of chopping product. Expected that robotic simulation will give a perfect result, so that the flow of suggested system is as followed:
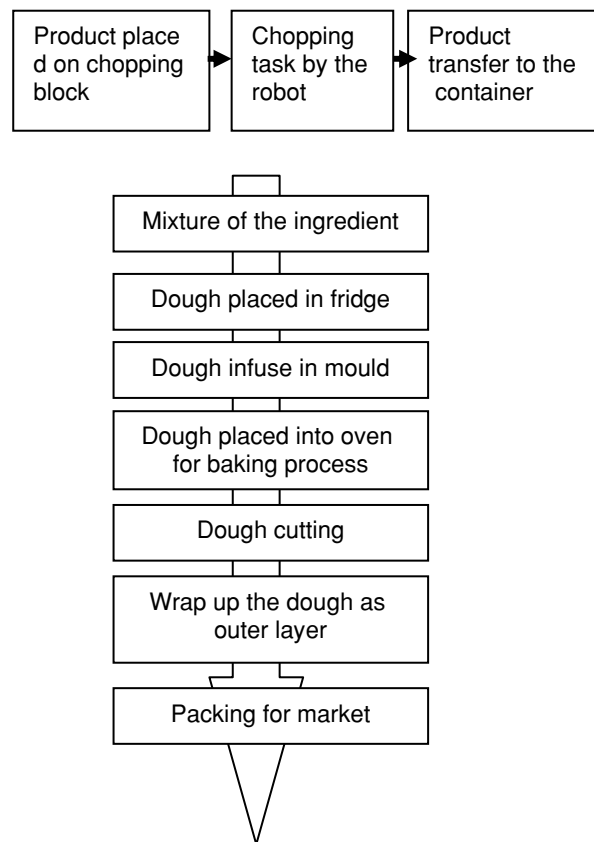
```
┌────────────┐   ┌───────────┐   ┌────────────┐
│Product plac │→ │Chopping    │→ │Product     │
│d on chopping│   │task by the │   │transfer to the│
│block        │   │robot       │   │container   │
└────────────┘   └───────────┘   └────────────┘
```

```
┌──────────────────────────────┐
│   Mixture of the ingredient   │
└──────────────────────────────┘
              │
┌──────────────────────────────┐
│     Dough placed in fridge    │
└──────────────────────────────┘
              │
┌──────────────────────────────┐
│     Dough infuse in mould     │
└──────────────────────────────┘
              │
┌──────────────────────────────┐
│   Dough placed into oven      │
│      for baking process       │
└──────────────────────────────┘
              │
┌──────────────────────────────┐
│         Dough cutting         │
└──────────────────────────────┘
              │
┌──────────────────────────────┐
│    Wrap up the dough as       │
│        outer layer            │
└──────────────────────────────┘
              │
┌──────────────────────────────┐
│      Packing for market       │
└──────────────────────────────┘
```

Figure 1: Flow of the manual process

3. Methodology

Kinematic simulation is a simulator system technique which is the situation on its continuous change is depends on movement for one or more kinematic tools. A common example in system is robot working envelope and machine with a few component movements. This structure customary is a major part in production system. Analysis from previous simulation model generally is in talent motion estimation for one or more tools. Robot that afford to fulfilled task without any collision detection, optimal path solution and correct and static of the robot base is an aspect of typical example in findings.

The simulation process contains of few step, which are problem identification, model formulation and development, computer modeling, verification and validation, experimentation and output analysis and decision support and implementation [1].

Another similar methodology is introduced by Grajo [5] that consist of eight phases are stated in Figure 2 below:
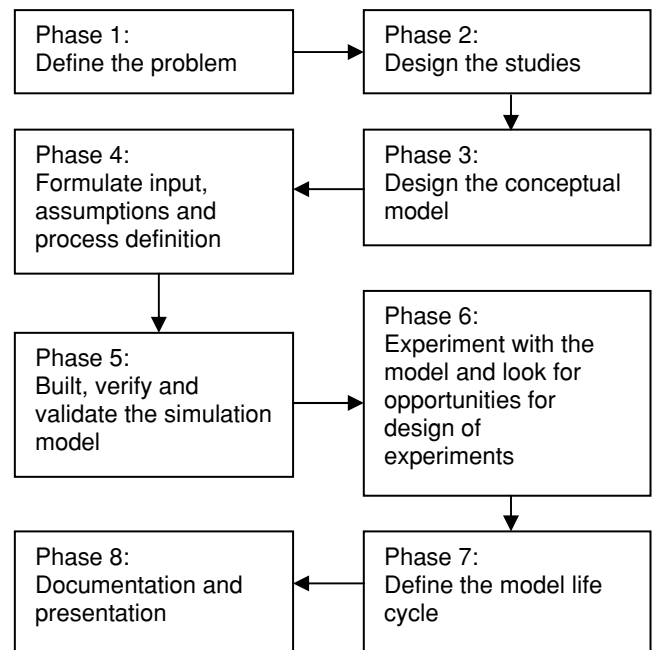
```
┌──────────────────┐      ┌──────────────────┐
│Phase 1:           │  →  │Phase 2:           │
│Define the problem │      │Design the studies │
└──────────────────┘      └──────────────────┘
                                    │
┌──────────────────┐      ┌──────────────────┐
│Phase 4:           │  ←  │Phase 3:           │
│Formulate input,   │      │Design the conceptual│
│assumptions and    │      │model              │
│process definition │      │                   │
└──────────────────┘      └──────────────────┘
        │
┌──────────────────┐      ┌──────────────────┐
│Phase 5:           │  →  │Phase 6:           │
│Built, verify and  │      │Experiment with the│
│validate the simulation│   │model and look for │
│model              │      │opportunities for  │
│                   │      │design of          │
│                   │      │experiments        │
└──────────────────┘      └──────────────────┘
                                    │
┌──────────────────┐      ┌──────────────────┐
│Phase 8:           │  ←  │Phase 7:           │
│Documentation and  │      │Define the model life│
│presentation       │      │cycle              │
└──────────────────┘      └──────────────────┘
```

Figure 2: The simulation methodology [5]

3.1. The simulation model

The simulation model applied in this project is based on the methodology proposed by Grajo [4]. Eight phases are identified based on their essential and necessity. The methodology is required to examine attentively the current system, so that it can be performed in operation. This will help on problem identification and detection if it is occurred as well as problem definition.

Phase 1: Monitoring operation and identifying problem

Monitoring the chopping process and identifying problems in the process are performed to define the actual problems. It shows that the quantity of product chopped is not optimized and the customer demand is not fulfill because of lack of workforce number and efficiency.

Phase 2: Robot selection

Based on the problem defined in Phase 1, selection of a suitable robot is required. Robot selection is an important phase where the robot must be able to perform the chopping process in the defined environment. A Cartesian robot that possesses three axes, X, Y and Z, has been chosen for this problem but only two axes, X and Z, are required.

Phase 3: End effecter design

Once the Cartesian robot is selected, end effecter of the robot must be designed to ensure the end effecter can do the chopping process effectively. The end effecter for the robot is a cutter. The cutter is designed in thin and light, so that the robot can execute the chopping process smoothly without huge burden.

Phase 4: Design robot and its environment

Based on the information obtained in Phase 2 and 3, the design of the robot, the cutter and its environment are continued. Since there are only two axes involved, the design of the robot and the cutter is simple and straightforward. For the environment, there are there entities identified namely table, chopping block and raw material. In this phase, the design of the robot, the cutter and the environment is perform without simulation yet.

Phase 5: Robotic simulation

After the design phase completed, Workspace5 is used in simulating the robot. Workspace5 allowed movement of the robot and changes if any. During the simulation process, moving parts can be shown in advanced. Besides, testing and validation also can be performed during the simulation process.

Phase 6: Testing

Testing phase is required to make sure each movement are in safe mode and will not collapse if any collision happens. Testing is a compulsory to prove that the robot simulation do the chopping process smoothly, precisely and no malformation to the product.

Phase 7: Comparisons

In order to achieve the target, comparing the results from two different models is required. Comparison results proved that the robot usage is better than

workforce. These comparisons considered efficiency, speed, optimum time and cutting quantity.

3.2. Implementation using Workspace5

This section explains the implementation of this project consisted of modeling the robot and its environment, and the simulation of the chopping process. The implementation is using robotic simulation software, Workspace5. The software is chosen because it provides flexibility for inventor to have their own interactive and visual environment in designing a trustable cycle time.

It also fit to lots of convenient such as CAD, GPs, Paths, simulation and VBA code that will help on developing the model simulation. The flow of the project implementation is explained below.

3.2.1. Modeling

The workspace of the robot is 90cm x 25cm x 10cm. Figure 3 shows the design concept of the Cartesian robot for simulation:
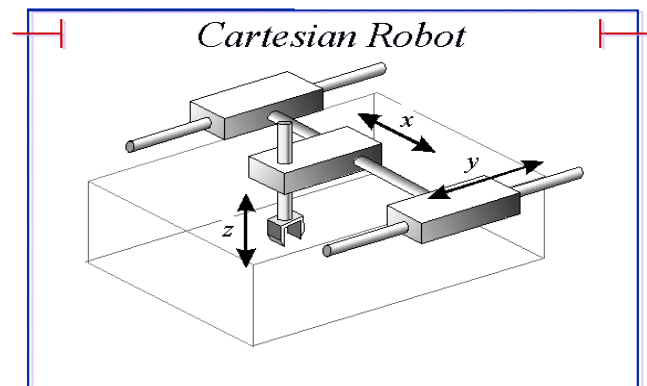

Figure 3: Cartesian robot

Based on the concept of the Cartesian robot, the entities of each part are developed using basic element of solid modeling features of workspace5. Development of Robotic simulation in this system consists of six parts of robot entity known as Rail, Base, Platform, Link, body and Cutter. The environment is consisting of four parts that is table, indicator, product and chopping block. Figure 4 shows the model design in workspace.

Base: Hold the link and control the blade along the rail.
Platform: Carry the base along the rail.
Rail: As a path to the robot.
Body: Hanging the model during the cutting process.
Link: Hold the cutter.
Cutter: Chop the product (pair for double result).
Table: Hanging the robot.

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Indicator: Start line to placing the product.
Product: Substance to chop.
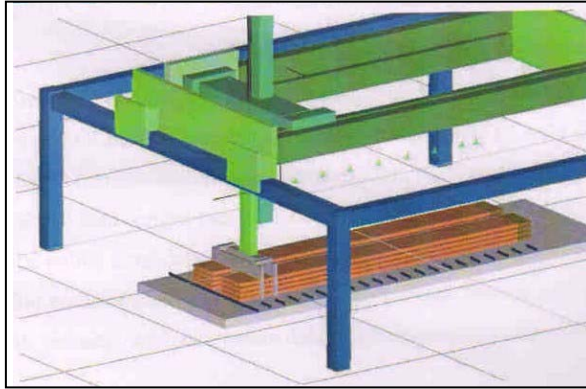Chopping block: Product placement during the
    chopping process.

Figure 4: Model design

Detail dimension for each robot part are shows in figure 5 to 11 below. Dimension help on facilitating real model development.
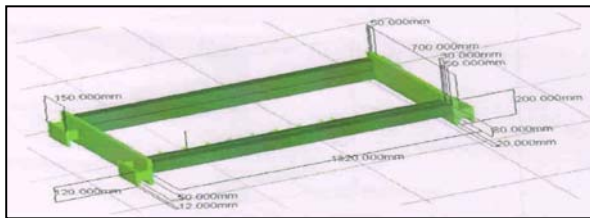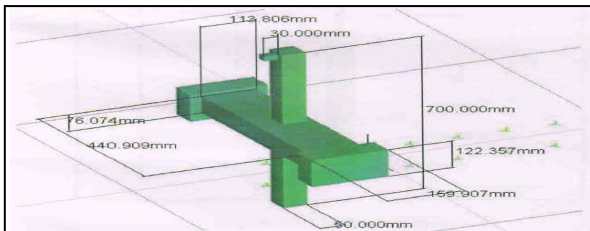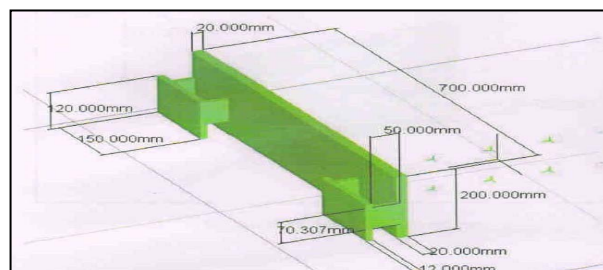

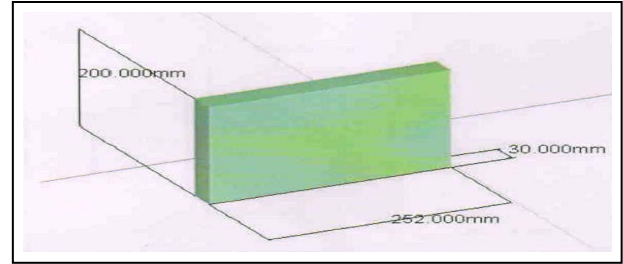**Figure 5: Rail**

Figure 6: Base

Figure 7: Body

Figure 8: Platform
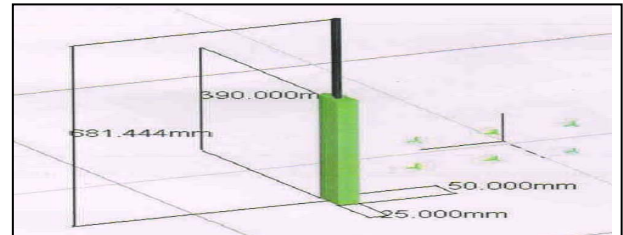
Figure 9: Link
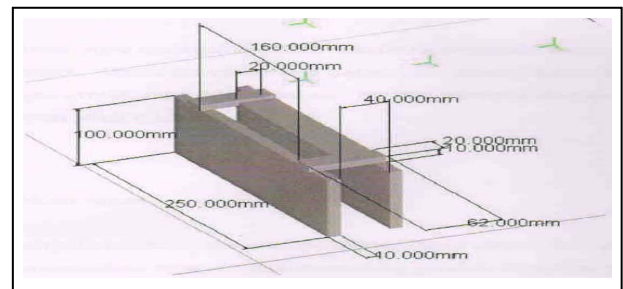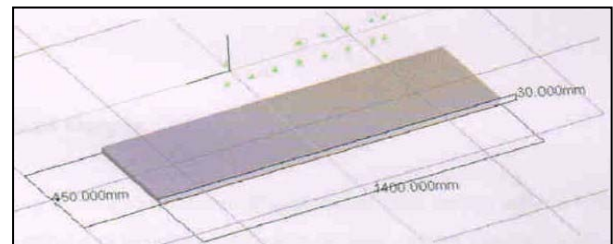

Figure 10: Blade

Figure 11: Chopping block

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3.2.2. Building device model

Device model represent actual work cell component and categorized into three, robot, robot environment and end effecter. Building the simulation robot model starts with the base part. The base coordinate is used in positioning the base part model of the device model. Then, the other part of the simulation robot model is to be selected and attached to the base part model. The robot simulation consists of two links that shows in table 1 below. These links are attached accordingly to its number by using the attachment feature of workspace5. Each attached link is subjected to parent and child relationship. Attachments for each part start from base and final with cutter.

There is a limitation to the robot on its movement, which the axes have their own end point. Figure 12 show the limitation for robot movement.
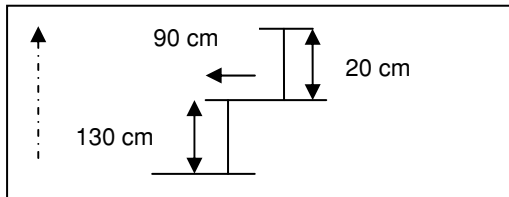

Figure 12: Limitation of movement

Table 1: Parent and child relation

Component	Parent	Child
Base	Base	Link1
Rail	Rail	Platform

3.2.3. Positioning device model

The layout of the simulation robot model environment represents the actual environment. This layout can be translated and rotated based on base coordinate system. If the translation performed absolutely to the world coordinate system, the operation represents an absolute positional measure between base coordinate system [6]. In Workspace5, translation is considered as joint. The simulation robot has same joint type but different value of the motion limit. Table 2 below shows the joint type and link limitation value for each joint.

Table 2: Link limitation value

	X	Y	Z	Roll	Pitch	Yaw	Joint Type
Basedlink (Joint 1)	330	300	410	-	-	-	Translational
PlatformRail (Joint 2)	6.452	-26.541	400	-	90	-	Translational
Base_world	330	300	410	-	-	-	-
Base_flange	360	300	260	-	-	-	-

3.2.4. Executing simulation environment

Execution of the simulation and analysis is using Workspace5. The simulated model is capable to view the movement of robot, layout checking, robot reach abilities, cycle time monitoring and collision [3]. The simulation focuses on the chopping process. The behavior of each device during the chopping process is programmed in the simulation using the Workspace5. The Workspace5 is the programmable software that allowed the robot to done the chopping process followed the instruction.

The steps perform in order to conduct simulation run is defining the geometrical point. By defining the geometrical point, the sequence of path for end effecter can be executed. The end effecter can simulated itself based on the sequence of the path. Simulation log will be generated during the programmed run.

4. Simulation and testing result

In section above, explained that geometrical point must be identifying to move the simulation robot from point to point. These movements indicate from origin to the product that is situated at chopping block and back to the origin.

This geometrical point are identify using teach pendant. There's three (3) ways on indentifying the geometrical point, which are using teach pendant (enter value for each joint) or find the absolute value X, Y and Z or using mouse. The best technique is using the absolute value, where values are referred to the coordinate point. There's 20 geometric points has been defined in this robotic simulation implementation.

After this process, robotic simulation is functioned. For each movement, programming codes recorded to show that the cutting process is done. Any collisions are detected.

4.1. Testing

Observation and data recorded during the simulation running process has been completed. From the observation, speed of the robot during the chopping

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process, quantity of chopping product and accuracy on measurement the product is the main focuses. Results from the simulation process are used during the validation. Chopping speed on the original system (workforce) cannot be determined because has been done manually. Because of the reason, comparisons focus on quantity of chopping product. Table 3 below shows the result after simulation and testing process.

Table 3: Simulation result

	Speed	Quantity (pieces)	Total (2 hours)
Current value	-	80 – 100	6400 – 8000
Simulation value	0.1m/s	160 – 200	24000

4.2. Cycle time

Cycle time referred to total of time taken by the simulation robot in completing the chopping process. Data is collected from the beginning till the end. During the simulation process, cycle time is recorded and the simulation log is also generated. From the simulation, knowable that a complete cycle time on cutting process takes 33:45 seconds.

4.3. Animation

An animation during simulation can be created. The animation is in AVI format. Figure 13 below shows the view of an animation.
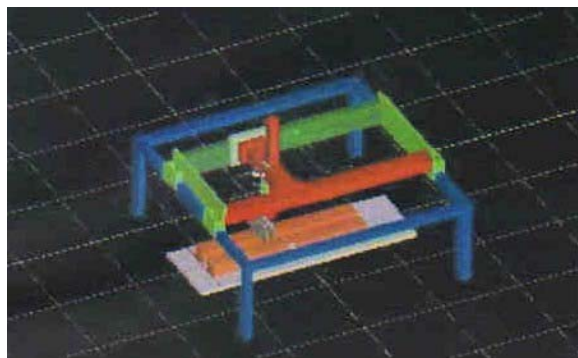

Figure 13: Animation

5. Conclusions

Designing and simulating the chopping process has been develop to test and prove that robot applications in doing cutting task will give the huge impact in production compared to human workforce. Based on testing and implementation, prove that robot usage is more meaningful. Visual simulation aims to make model looks like the real world it represents. As the model runs, user can see how the movement and the chopping was process.

There are the numbers of advantages, chopping task is accurate and effectives, product chopping quantity are increase and product size is precise.

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