IN THE NAME OF GOD

DESIGN OF A LONG REACH HYDRAULIC BACKHOE EXCAVATOR FOR SPECIAL TASK BASED ON ROBOTIC SIMULATION

BY

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Dedicated To

My Dear Family For Their Kindness

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ABSTRACT

DESIGN OF A LONG REACH HYDRAULIC BACKHOE EXCAVATOR FOR SPECIAL TASK BASED ON ROBOTIC SIMULATION

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The usual task of an excavator is to free and/or remove surface materials, such as soil, from its original location and transfer it to another location by lowering the bucket, digging, pushing and/or pulling soil, then lifting, swinging and emptying the bucket. The excavation of this task is usually performed by standard hydraulic excavators manufactured for commercial purposes.

However, to design a new excavator and/or redesign an existing one to change it into higher capacity and longer reach for special task, it is necessary to develop the appropriate dynamic and kinematic model for the machine. In another word, to analyze and plan the motion of an excavator for performing a special task, the development of an accurate computer model is essential to describe the kinematics and dynamics of the excavator for transferring surface material.

This research work has aimed to present the explicit expressions for the forward and backward (inverse) kinematic relations of a

hydraulic excavator while the bucket of the machine follows a prescribed path geometry and trajectory cycle specified by its position and the bucket lift and digging angles.

The proposed dynamic model is based on Newton-Euler's equations of motion and describes the excavator motion with time, which in turn, evaluates the instantaneous general forces at each joint and link. In addition, in the worst scenario the types of pins and the actuators will be selected.

Moreover, the aforesaid robotic model is intended for further development to a robotic system able to perform the planned digging work and automated excavations control system for effective use in the dark, severe weather, hazardous and/or unhealthy environments.

Finally, the implementation of the presented model has been illustrated by means of numerical examples. All of the findings of the cases solved by the proposed algorithm are presented and compared with the results of the similar problems solved by the commercial code **"Working Model"** as well as the reported standard data and a close agreement has been notified.

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INTRODUCTION

1.1 EXCAVATORS

Excavators are intended for excavating rocks and soils. Excavators may have a mechanical or hydraulic drive.

Hydraulic excavators are the most important group of excavators. A typical hydraulic backhoe excavator linkages is shown in Fig.(1.1). It consists of four link members: the bucket, the stick, the boom and the revolving superstructure (upper carriage).

There is an almost limitless range of sizes of backhoe, from hoes mounted on small agricultural tractors used in residential construction all the way up to huge crawler-mounted hoes capable of handling some of the heaviest work in industrial jobs. These excavators are also operated with other attachments such as clamshell, dragline, drilling equipment, scarifies for breaking pavements and frozen soils. On the other hand, the work functions of the backhoe often overlap those of other machines such as front-end loaders, tractor shovel, scrapers, clamshells and draglines. In addition, it is particularly useful for trenching foundation footing excavation, basement excavation and similar works.

The useful task of backhoe hydraulic excavator is to free and/or remove surface materials such as soil, from its original location and transfer it to another location by lowering the bucket, digging, pushing and/or pulling soil then lifting, swinging and emptying the bucket. The excavation of this task is usually performed by a human operator who controls the motion of the machine manually by using the visual feedback provided through his or her own eyes.

In many current applications of excavations, the semiautonomous applications or even automatic operation of the machine is desirable and sometimes even necessary. Automation of excavation control system for effective use in the dark severe weather, hazardous and/or unhealthy environments, terrestrial, lunar and planetary excavation calls for a robotic system able to perform the planned digging work. Based on the aforementioned argument, the development of an accurate computer model is essential to describe the kinematics and dynamics of excavator for transferring surface materials.

However, to analyze and plan the motion of the excavator for performing a specific task , it is necessary to develop the appropriate dynamics & kinematics models for the machine.

In this research work , an excavator was modeled based on the robotic formulation, therefore the kinematics and dynamics algorithms for simulation of a manipulator robot were developed.

To analyze and plan the motion of the excavator, it's necessary to define a global coordinate system to describe the pose of the bucket and further to define local coordinate frames for all links using the DH guideline. The latter is commonly used in robotics for determining the structural kinematic parameters. Then, the homogeneous transformation matrix is conveniently obtained in the general form .

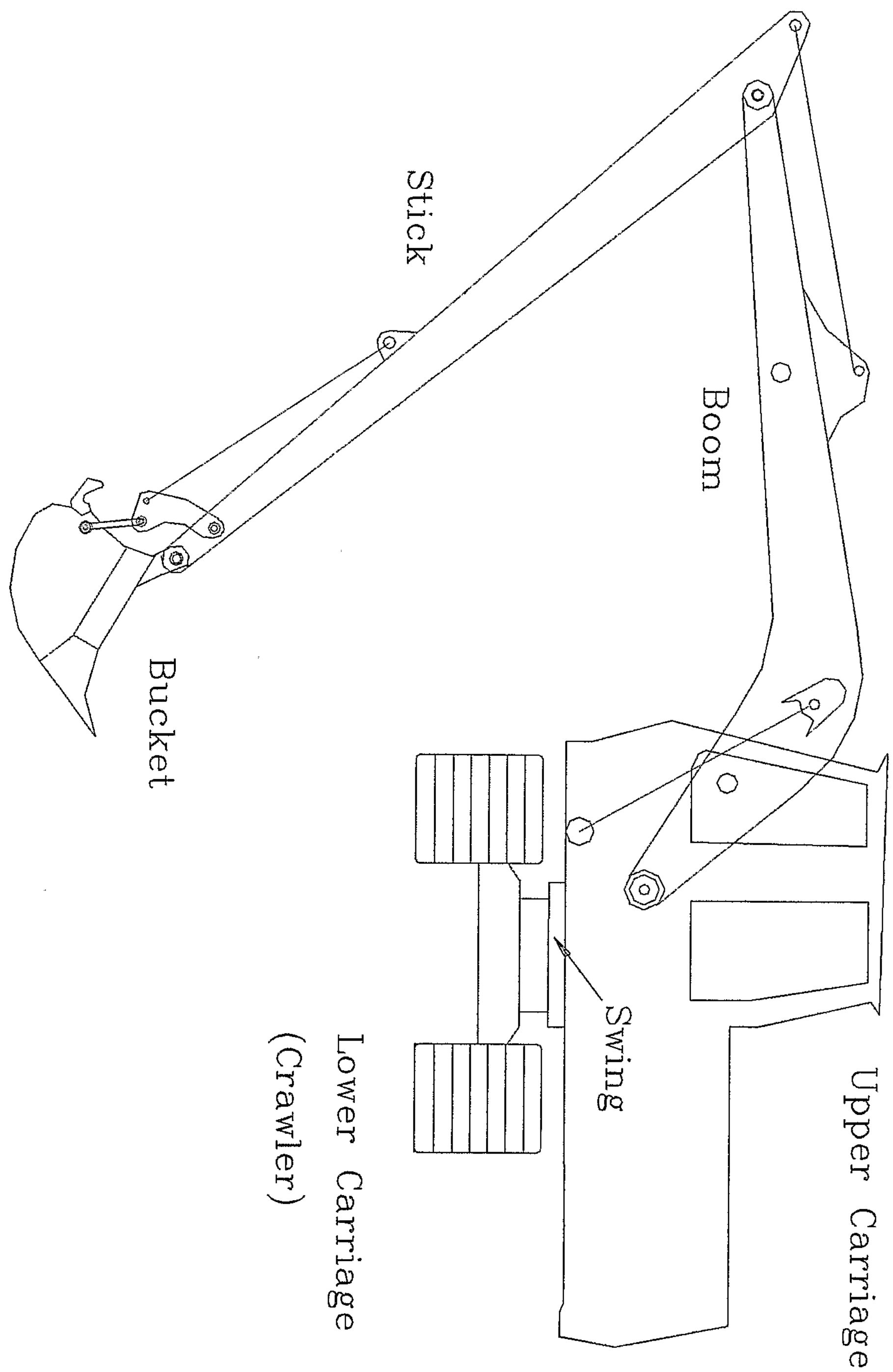

Fig (1.1) A typical hydraulic backhoe excavator

The mathematical expressions that relate the position and orientation of the bucket to the shaft positions and consequently to length of the piston rods in the hydraulic actuators are called the kinematic equations .The aforesaid equations are used to describe the forward and backward kinematics of an excavator.

With regards to the dynamic modeling of an excavator, Newton-Euler's formulation[1,2] has been adopted to describe the equations of motion. In dynamic simulation, the velocities and accelerations of each link were obtained, then forces and moments which act the links have been computed recursively by starting at the bucket and working backward to the base.

The dynamic model of an excavator presented here provides a useful computational platform to investigate the mechanical behavior of a typical excavator .