FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF WATER RESOURCES ENGINEERING

A SMART HYDROINFORMATIC SYSTEM FOR REAL TIME OPTIMAL OPERATION OF WATER DISTRIBUTION NETWORKS UNDER UNCERTAIN WATER DEMAND AND POWER AVAILABILITY.

by

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A project report submitted to the Department of Water Resources Engineering in partial fulfilment of the requirement for the award of the Bachelor of Science Degree in Water Resources Engineering at Busitema University

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ABSTRACT

More than 309 million people, mostly in developing countries around Africa, South America, and Asia, are experiencing the IWS (Li et al., 2020, Loubser et al., 2021, Erickson et al., 2017, Kumpel and Nelson, 2016). In an intermittent water supply that may occur daily, weekly, or seasonally, the drinking water is provided for less than 24 h per day to the consumers within the distribution network (Farmani et al., 2021).

The uncertainty in determination of the future available electricity, required water demand, and complexity in determining and actuation of optimal operation strategies while operating pumps, valves and tanks has led to Water distribution systems operating intermittently resulting to unequitable distribution of water to all customers.

If distribution systems are not optimised, there shall be a continued intermittent water supply due to routine scheduling and basing on experience, and since water demand and power availability are not put into consideration which in turn affects the flow rate and pressure of water reaching the customer is affected.

Real time optimisation of pumps, valves and tanks using the use of a genetic algorithm for optimisation of the system parameters and Epanet-Matlab toolkit for simulation. in water distribution systems has been carried out individually for each component but not for the three components together.

To extend the capabilities of the off-line monitoring researchers approached towards usage of Wireless Sensor Networks (WSN) technology is a collection of connected sensors that collect data from their environment.

While resolving some of the limitations of offline monitoring systems, this technology also has some limitations, such as low spatial resolution due to private network infrastructure, compromised security, energy requirements, storage issues, and high maintenance and installation costs. (Farmanullah Jan et al 2022). The smart hydroinformatic system forecasts water demand and electricity availability, optimises valve opening and pump switching on and off and monitoring and controlling and actuating pumps, valve and tanks wirelessly. This will help minimise operational costs and maximise system efficiency hence ensuring a reliable and suitable water supply system.

DECLARATION

I the undersigned, declare that this research proposal is my original work except where due acknowledgement has been made. I declare that this work has never been submitted to this university or any other institute for funding/ for partial fulfillment for any award.

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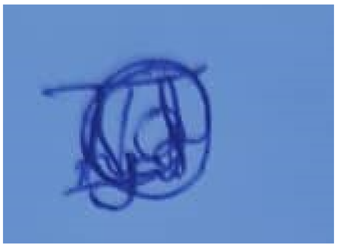
Signature…

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SUPERVISOR APPROVAL

This research proposal submitted as a partial fulfilment for the award of Bachelor degree of science and water resources engineering of Busitema University, with my approval as the academic supervisor.

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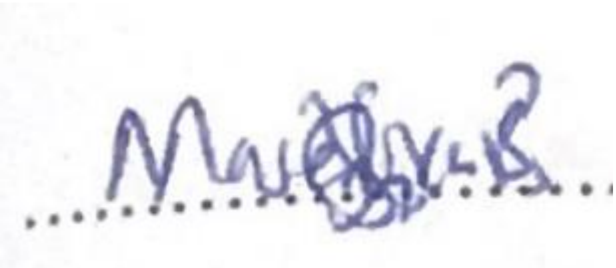
Signature: 

Qualification: LECTURER

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We take this opportunity to concede the almighty GOD for he has granted us life, good healthy and ability to research and gather information that is incorporated in this report.

We tender our authentic thankfulness to our lovely parents for the work well done in naturing us into responsible and hardworking people, we then thank them for their assiduous patronage in the various aspects of our lives most especially the academic aspect. May GOD bless you copiously.

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LIST OF ACRONYMS

AIC – Akaike Information Criterion

ANN – Artificial Neural Network

ARIMAX – Autoregressive Integrated Moving Average

ASA – Adaptive Search Algorithm

DAN2 – Dynamic Artificial Neural Network

DMAs – District Metered Areas

GA – Genetic Algorithm

MAPE – Mean Absolute Percentage Error

NHMC – Non-Homogeneous Markov Chain

NRMSE – Normalised Root Mean Square Error

NLP – Non-Linear Programming

QMMP+ - Qualitative Multi model Predictor Plus

SCADA – Supervisory Control And Data Acquisition System

SOM – Self Organising Maps

VFC – Variable Frequency Controller

VSP – Variable Speed Pumps

WDNs – Water Distribution Networks.

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1. CHAPTER ONE: INTRODUCTION

This chapter includes; back ground to the study, statement of the problem, objectives of the study, scope of the study which includes the conceptual scope, geographical scope and time scope and finally the significance of the study.

1.1. Background

In the earth, water is a very vital commodity needed for survival of all life form. It can be used for irrigation, drinking, cooking, power production, recreation, machine cooling and cleaning of raw materials in industries. This commodity is supplied to the consumers through water distribution networks (WDNs) arranged in branched, looped, or combined system formation which form part of the primary infrastructure belongings of the general public (Poulakis, Valougeorgis, & Papadimitriou, 2003). The process of water supply involves the following steps; collecting, storing, pumping and transporting water through WDNs. The elements of water WDNs are reservoir, pumps, tanks, pipes, valves etc (Esiefarienrhe & Effiong, 2014).

Centralized water distribution in developing countries continues to be fraught with great difficulties. One major deficiency is the intermittent distribution of water. Most distribution systems operate intermittently because of various constraints among which include electricity breakouts, drought, unplanned expansion of the network resulting from ever increasing population, insufficient system data to inform an optimal operation of the distribution network, excessive water losses and insufficient water resources (Klingel, 2012). IWS also exists because there is not enough capacity to pressurize the system to supply all consumer taps at the same time, and due to the leaky infrastructure.

Despite significant international efforts, about 30% of water distribution systems in Africa, more than 50% of systems in Asia, and about 60% of systems in Latin America do not consistently provide their users. It is even estimated that 90% and almost 100%, respectively, of water distribution systems in Southeast Asia and India operate intermittently (Simukonda et al., 2018).

Intermittent water supply in water distribution networks has several short comings including water quality degradation and cause waterborne diseases as contaminants enter the pipes through the leakages, accelerated water network depreciation and operational and maintenance costs due to repetitively turning on and off of the water supply in the system, un even distribution of water and reducing the efficiency of water supply (Nyahora et al., 2020). The requirement to purchase storage tanks, clean or boil water, or cope with waterborne diseases

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