

**LASER RANGE FINDER SCANNING SYSTEM FOR
TREE DIAMETER AND CIRCUMFERENCE MEASUREMENT**

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**Bachelor of Mechatronics Engineering
June 2012**

“ I hereby declare that I have read through this report entitle “*Laser Range Finder Scanning System for Tree Diameter and Circumference Measurement*” and found that it has comply the partial fulfilment for awarding the degree of “*Bachelor of Mechatronics Engineering*”.

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CIRCUMFERENCE MEASUREMENT**

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**A report submitted in partial fulfilment of the requirements for the degree
of Bachelor of Mechatronics Engineering**

**Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

YEAR 2012

I declare that this report entitle “*Laser Range Finder Scanning System for Tree Diameter and Circumference Measurement*” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Chan Xin Zhi

Date :

To my beloved family

Acknowledgement

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ABSTRACT

Many methods had been developed to measure the diameter of tree in order to calculate its circumference. Tree diameter and circumference measurement are important for Estate Company to determine tree growth and when it is available for tapping. Biltmore Sticks, Calipers, Diameter Tape, Relaskop, Wheeler's Pentaprism, Wedge Prism and Criterion Laser 400 Dendrometer are popular dendrometers used for measuring diameter and circumference of tree. Nevertheless, these dendrometers have their weakness in the measurement process. Laser Range Finder is one of the laser sensors widely used by researchers for different purposes. This project is to develop an algorithm for tree diameter and circumference measurement using data recorded from Laser Range Finder with Graphic User Interface (GUI) environment. The newly developed measurement device is named Laser Metric. Experiments had been conducted by measuring tree to test the accuracy of Laser Metric when held with hand and fixed to the ground by varying distances. Graphs of accuracy versus distance are drawn to show the result of Laser Metric measurement capability.

ABSTRAK

Terdapat pelbagai cara yang diperkembangkan untuk mengukur diameter pokok supaya lilitan pokok boleh dikira melalui diameter. Pengukuran diameter dan lilitan pokok penting untuk Syarikat estet untuk menentukan kesuburan pokok dan untuk menentukan persediaan menoreh pokok. Biltmore Sticks, Calipers, Diameter Tape, Relaskop, Wheeler's Pentaprism, Wedge Prism dan Criterion Laser 400 Dendrometer merupakan dendrometer yang terkenal digunakan untuk mengukur diameter pokok. Walaubagaimanapun, dendrometer-dendrometer ini mempunyai kelemahan tersendiri dalam proses pengukuran. Laser Range Finder merupakan salah satu pengesan laser yang luas digunakan oleh penyelidik-penyelidik untuk pelbagai tujuan. Oleh sebab itu, projek ini bertujuan membentuk algoritma untuk ukuran diameter dan lilitan pokok melalui data yang dikumpulkan oleh Laser Range Finder dengan Graphic User Interface (GUI). Alat pengukuran yang dimajukan ini diberi nama Laser Metric. Eksperimen-eksperimen dijalankan untuk menguji kejituan Laser Metric apabila dipegang dengan tangan dan apabila ditetapkan di atas lantai. Graf kejituan lawan jarak dilukis untuk menunjukkan kecekapan Laser Metric.

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LIST OF ABBREVIATIONS

- GUI – Graphic User Interface
LRF – Laser Range Finder
RM – Ringgit Malaysia
UTeM – Universiti Teknikal Malaysia Melaka
i.e. – That is
etc. – Etcetera

LIST OF SYMBOLS

m	–	Meter
mm	–	Milimeter
cm	–	Centimeter
nm	–	Nanometer
°	–	Degree
g	–	Gram
%	–	Percentage
θ	–	Theta
C	–	Celcius

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Chapter 1

1 Introduction

1.1 Project Background

Contact and non-contact measurement device have been developed for decades to measure tree diameter and circumference. These measurement devices are still considered to be time consuming and low in accuracy although forestry and plantation workers are still using one of these methods to measure tree diameter and circumference. Fast responding and accurate non-contact measurement device is needed for measuring tree diameter and circumference to help reduce time for measuring whole plantation. Accurate measurement device is required to determine the correct time for fertilization and time to tap of the tree measured.

1.2 Problem Statement

Available contact methods used to measure tree diameter and circumference do not consist of Graphic User Interface (GUI) and time consuming. Contact methods include the use of diameter tape, callipers and Biltmore sticks. Non-contact methods used for measuring tree diameter and circumference do not consist of GUI and low in accuracy. Relaskop, Wheeler Pentaprism and Criterion Laser Instrument are the example devices of non-contact methods. This causes measurement difficulty as well as affecting the result of measurement values. Rubber Industry Smallholders Development Authority (RISDA) is one of the estate developers in Malaysia who faces difficulty when dealing with problem in measuring tree diameter and circumference of rubber tree. This is caused by massive amount of rubber trees to be measured using difficult and low accuracy measurement methods. In order to eliminate these problems, alternative method is researched to develop

a device that can help reduce time and achieve adequate accuracy in measuring tree diameter and circumference.

1.3 Objective

1. To develop an algorithm for tree diameter and circumference measurement using data collected from Laser Range Finder (LRF) with the help of GUI to show and record the value of diameter and circumference.
2. To reduce time and achieve adequate accuracy for tree diameter and circumference measurement.
3. To examine the performance of the device developed through experiments.

1.4 Scope

The scope of this project covers the design, development and testing of the tree diameter measurement device. The scopes include:

1. Laser Range Finder is used to scan 240 degree area of range within 0m to 3m for data recording. Laptop is used for data processing.
2. Data recorded is used for calculating diameter and circumference of tree via algorithm developed using C++ language.
3. Testing the performance of the device.

Chapter 2

2 Literature Review

2.1 Introduction

There are various methods used for measuring tree diameter and circumference. These methods include the use of Biltmore stick, caliper, Relaskop, diameter tape, Wheeler pentaprism, wedge prism and Criterion Laser Instrument. Dendrometers are the terms used to define contact and non-contact measurement device used especially in measuring tree diameter and circumference. This section discusses the advantages and disadvantages of these methods.

2.2 Methods to Measure Tree Diameter or Circumference

Diameter of the standing tree need to be measured using standard Diameter at Breast Height (DBH) method where the measurement needs to be done at DBH defined height[6]. DBH used is different for different countries. DBH used in Malaysia is 1.4m. Diameter of the tree measured can be used for tree circumference calculation with the equation $2\pi d$ (where d is the diameter).

i. Biltmore Stick

Biltmore Stick is one of the methods used to measure diameter of fallen tree and standing tree (at DBH) but its measurement is considered rough estimation. Calibration distance for Biltmore Stick is approximately 60 cm from the tree to user[1]. The stick need to be held at DBH. User aligns the zero point of the Biltmore Stick to match the left edge of the stem. The measured diameter is then read from zero point till the right edge of the tree. Formula use to calculate the actual diameter is,

$$\text{Measured diameter} = \text{actual diameter} \sqrt{\frac{60\text{cm}}{60\text{cm} + \text{actual diameter}}} \quad (2.1)$$

ii. Caliper

Caliper is another one of the methods used to measure diameter of fallen trees. Circumference of the tree can be calculated with diameter measured. Aluminium Callipers are commonly used for measuring the tree diameter but its accuracy needs to be identified[1]. Caliper needs to be calibrated each and every time before used for measuring tree diameter for accuracy to minimize the error of the measurement taken.

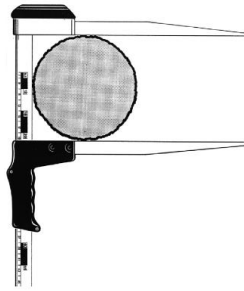


Figure 2-1: Caliper

iii. Relaskop

Relaskop is considered as one method currently used for tree diameter measurement. The distance to measure the tree diameter must be fixed before measurement starts. There is a peephole built for the Relaskop which is used for viewing tree[1]. Visible vision for viewing object is on the upper half of the peephole lens while the other half is the measure band (see Figure 2-2).

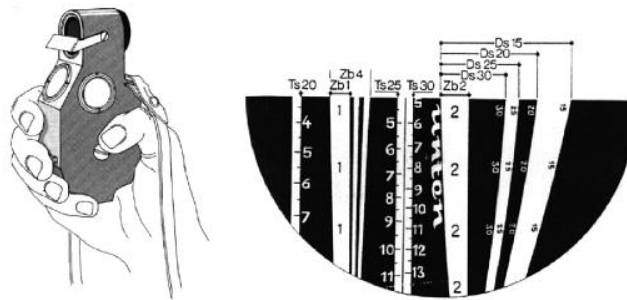


Figure 2-2: Relaskop

iv. Diameter Tape

Diameter tape is a tape divided on both sides with its linear side giving the true reading of tree circumference while the other side of the reading gives matching diameter reading. Small systematic error produced when measuring the tree diameter above or below DBH[1]. Diameter tape is considered by forestry as one of the most accurate measurement device. Most forestry and plantation workers in Malaysia assume diameter tape produces 100% accurate.

v. Wheeler Pentaprism

Another method used to measure tree diameter at DBH is by using Wheeler's Pentaprism. Viewing slot of the Wheeler Pentaprism is seen through by users to view the left edge of the tree which is on the upper image and right edge of the tree which is on the lower image. When the movable prism of the Wheeler Pentaprism is moved until the left edge and right edge coincide, diameter is shown by the pointer[1].

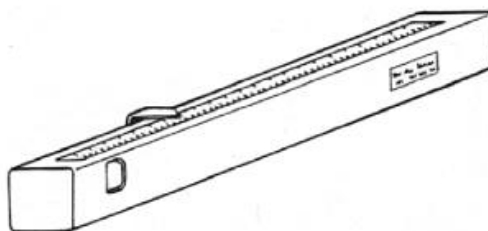


Figure 2-3: Wheeler Pentaprism

vi. Wedge Prism

Another method used to measure tree diameter commonly used because of low cost is wedge prism. Material used for wedge prism is glass or plastic which can reflect light with constant angle[1].

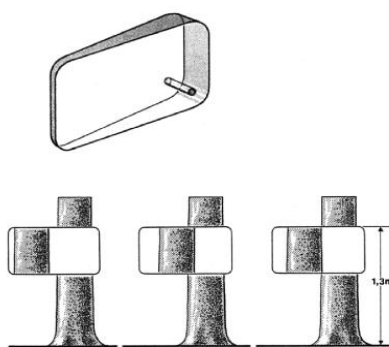


Figure 2-4: Wedge Prism

vii. Barr and Stroud Dendrometer

Barr and Stroud Dendrometer is a coincident and highly magnifying dendrometer. It is a high precise dendrometer but also the most expensive in terms of time and instrument expense[1]. The accuracy of this dendrometer is subject up to error of 3mm. This dendrometer does not measure tree diameter directly but rather obtain the reading through vernier scale and inclinometer. The readings obtained are converted to diameter through table provided with the dendrometer[1].

viii. Criterion Laser Instrument

Criterion Laser Instrument uses laser beam to measure tree diameter and circumference. This is the advance method used by forestry researchers to measure diameter of tree using laser technology but its cost is around \$11000 which is considered as costly tool used for measurement[5]. It requires researchers to manually keying in diameter measurement data recorded in Secure Digital (SD) memory card into computer for further data analysis.