

TABLE OF CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
	ABSTRACT	iii
	LIST OF TABLES	xiii
	LIST OF FIGURES	xv
	LIST OF SYMBOLS AND ABBREVIATIONS	xx
1	INTRODUCTION	1
	1.1 GENERAL	1
	1.2 BRIEF REVIEW OF LITERATURE	4
	1.3 OBJECTIVES	10
	1.4 OUTLINE OF THESIS	10
2	FRUITS CONVEYOR SYSTEM	14
	2.1 INTRODUCTION	14
	2.2 ORIENTATION MECHANISM	15
	2.2.1 Vertical Orientation Unit	16
	2.2.2 Horizontal Orientation Unit	21
	2.3 DEVELOPMENT OF INTEGRATED CONVEYOR	25
	2.3.1 Fruit Feeding and Singulation	25
	2.3.2 Fruit orientation	29
	2.3.3 Conveying	29

CHAPTER NO.	TITLE	PAGE NO.
	2.3.4 Design considerations	30
	2.3.4.1 Friction Belt Speed	30
	2.3.4.2 Component Colour	32
2.4	CONCLUSIONS	32
3	ILLUMINATION SYSTEM	33
3.1	INTRODUCTION	33
3.2	REVIEW OF ILLUMINATION SYSTEMS	34
	3.2.1 The Light Sources	35
	3.2.2 Forms of Lighting	37
	3.2.2.1 Front Lighting	38
	3.2.2.2 Backlighting	38
	3.2.2.3 Structured Lighting	40
3.3	IMPROVED ILLUMINATION SYSTEM	40
	3.3.1 Source Selection	42
	3.3.2 Parallel Illumination System	42
	3.3.3 Illumination Chamber	43
3.4	EXPERIMENTAL RESULTS AND DISCUSSIONS	46
	3.4.1 Spectral Measurement	47
	3.4.2 Analysis With Reflectance Standards	50
	3.4.3 Analysis for Colour and Uniform Intensity	54
	3.4.4 Analysis With Delrin Ball Images	56
3.5	CONCLUSIONS	61

CHAPTER NO.	TITLE	PAGE NO.
4	IMAGING SYSTEM	62
4.1	INTRODUCTION	62
4.2	STUDY OF IMAGING COMPONENTS	63
4.2.1	Camera Features	63
4.2.1.1	Technology	63
4.2.1.2	Resolution	63
4.2.1.3	Frame Capture Rate	64
4.2.1.4	Spectral Sensitivity	64
4.2.1.5	Non-Linearity	65
4.2.1.6	Clipping	65
4.2.1.7	Blooming	66
4.2.2	Lenses	66
4.3	DEVELOPMENT OF IMAGING SYSTEM	68
4.3.1	Camera Selection	68
4.3.1.1	Camera Calibration	70
4.3.1.2	Camera Field-Of-View	74
4.3.2	Choosing a Lens Focal Length	75
4.3.3	Frame Grabber Card	77
4.3.3.1	External Trigger	78
4.3.3.2	Frame (Region Of Interest)	78
4.3.3.3	Digital Input and Output Signals	79
4.3.3.4	Synchronisation	79
4.4	SEGMENTATION	84
4.5	CONCLUSIONS	88

CHAPTER NO.	TITLE	PAGE NO.
5	FRUITS SIZE MEASUREMENT	89
5.1	INTRODUCTION	89
5.2	CONTOUR EXTRACTION	91
5.3	EVALUATION METHODS	91
	5.3.1 Calculation of Tilt	93
	5.3.2 Circle Method	94
	5.3.3 Parabola Method	96
	5.3.4 Ellipse Method	97
	5.3.5 Principal Axis Method	98
	5.3.6 Radius and Area Signature Method	101
	5.3.7 Coefficient of Variation Method	103
5.4	RESULTS AND DISCUSSIONS	104
5.5	CONCLUSIONS	107
6	FRUITS SHAPE MEASUREMENT	108
6.1	INTRODUCTION	108
	6.1.1 Region-Based Information	109
	6.1.2 Boundary Information	110
6.2	SHAPE COMPUTATION METHODS	111
	6.2.1 Radius Signature Method	111
	6.2.2 Area Signature Method	119
	6.2.3 Contour Vectors Method	126

CHAPTER NO.	TITLE	PAGE NO.
6.3	DATA ANALYSIS	131
	6.3.1 Correlation Technique	131
	6.3.1.1 Radius Signature Data Analysis	132
	6.3.1.2 Area Signature Data Analysis	132
	6.3.2 FFT Technique	133
	6.3.2.1 Radius Signature Data Analysis	134
	6.3.2.2 Area Signature Data Analysis	135
	6.3.2.3 Contour Vectors Data Analysis	138
6.4	CONCLUSIONS	140
7	FRUIT COLOUR	141
	7.1 INTRODUCTION	141
	7.2 COLOUR MODELS	142
	7.2.1 RGB Colour Space	142
	7.2.2 CIE Colour Space	143
	7.2.3 HSI Colour Space	144
	7.3 HISTOGRAM ANALYSIS	145
	7.4 HUE HISTOGRAM ANALYSIS	147
	7.4.1 Experimental Results	148
	7.5 LINEAR DISCRIMINANT ANALYSIS	151
	7.6 CONCLUSIONS	155

CHAPTER NO.	TITLE	PAGE NO.
8	SUMMARY AND CONCLUSIONS	156
8.1	GENERAL	156
8.2	REVIEW OF THE WORK DONE	156
8.3	SCOPE FOR FUTURE WORK	158
	REFERENCES	160
	LIST OF PUBLICATIONS	165
	VITAE	166