AUTOMATED GUIDED VEHICLE APPLICATION:

PRECISION AGRICULTURE

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Abstract

Nowadays, there are many types of automated guided vehicle (AGV) running in different field of industries. Typically their job is moving raw materials or parts around the manufacturing facility. And they can be very accurate in working by following the guide from the wires in the floor, magnets, laser, or vision. However, they all requires an indoor condition. Therefore, the purpose of this thesis report is to discuss the implement of the outdoor AGV. An outdoor AGV has much more constrains than indoor. The environment indoor can be easily controlled while the door is not. The condition could be rough ground, no preset guiding wire or magnets, vision blocking by dust, and so on. The solution, which will talk in this paper, to achieve the outdoor AGV is using laser or vision to guide. In addition, a buffer will be set to stabilize the cargo or others working devices, to prevent them from the shaking due to the rough ground. To be more specific, a prototype will be built to simulate the working of seeder. In agriculture, it is very important to plant corns in a straight line. It benefits not only in absorbing sunlight and ventilation, but also reduce the work of irrigation, fertilizing, and harvest. Because a straight line of corn also mean a straight line of aisle. And more importantly, to achieve unmanned agriculture, a corn field with straight line of aisle will be a good condition for other agriculture robots.

1 Introduction

1.1 Introduction to subject

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1.2 Importance of subject

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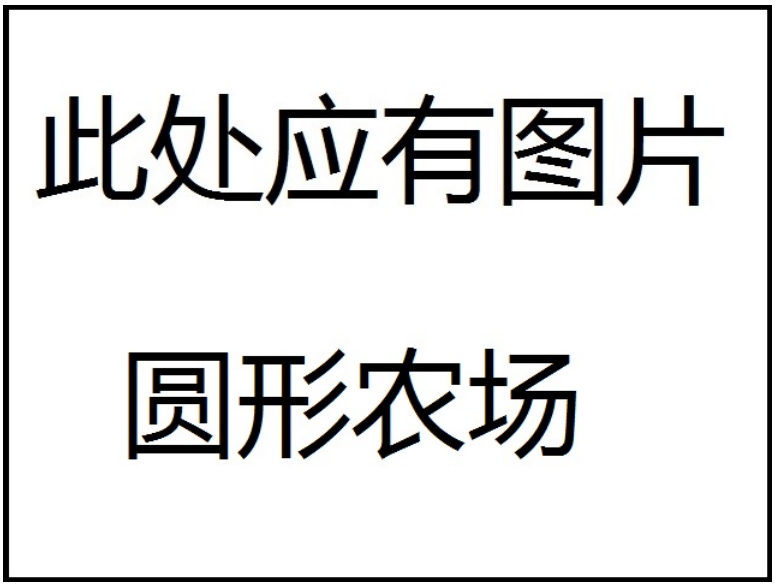

Figure 1: Farm

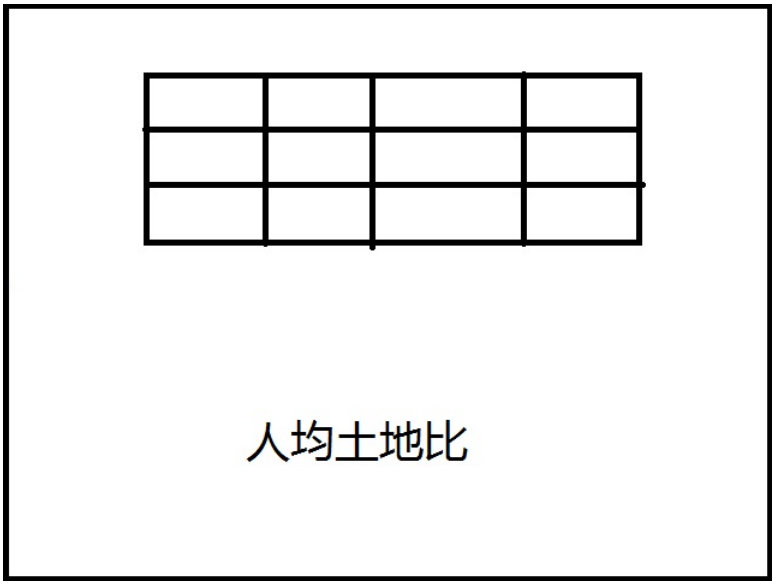

Table 1: Landratio

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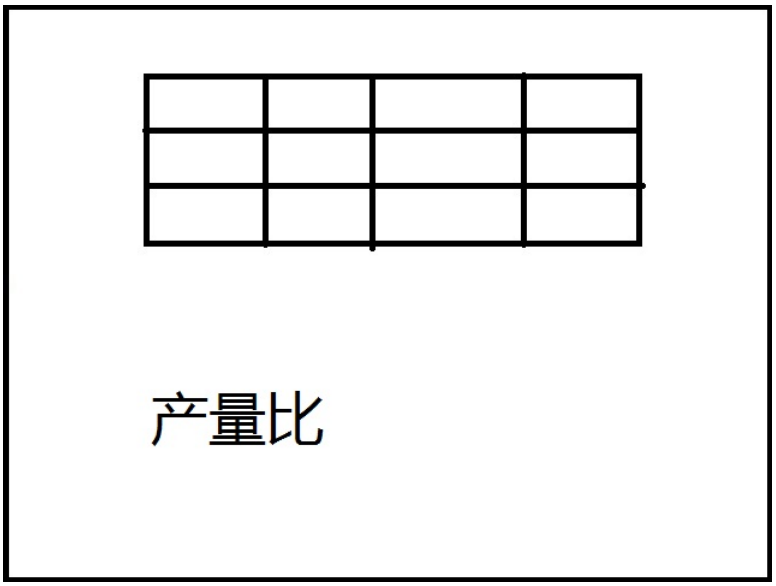

Table 2: Productivityratio

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2 Background

2.1 Related research

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2.2 Current understanding

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[Egbelu and Tanchoco, 1984] GPS7 23

2.3 Hypothesis or research question

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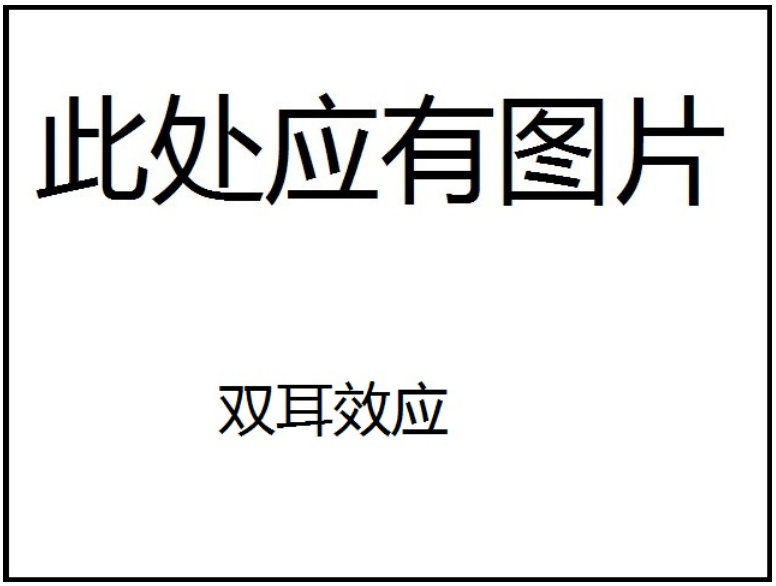

Figure 2: Twoears

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2.4 Intended project

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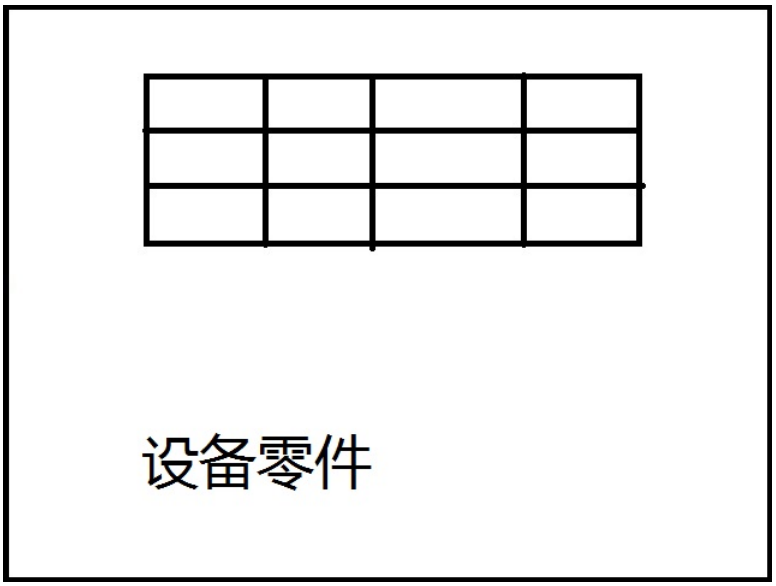

Table 3: Parts

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3.2 Laser guided

3.2.1 Imaging processing

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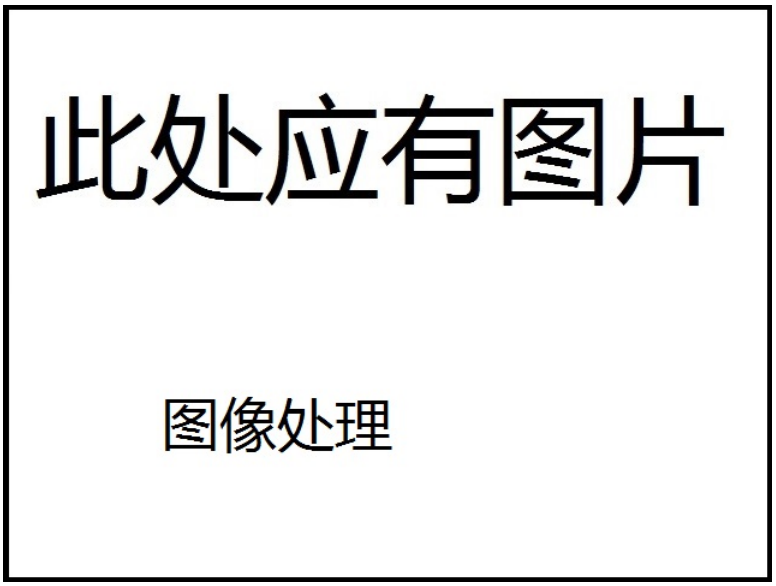

Figure 4: Imaging

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3.2.2 Buffer design

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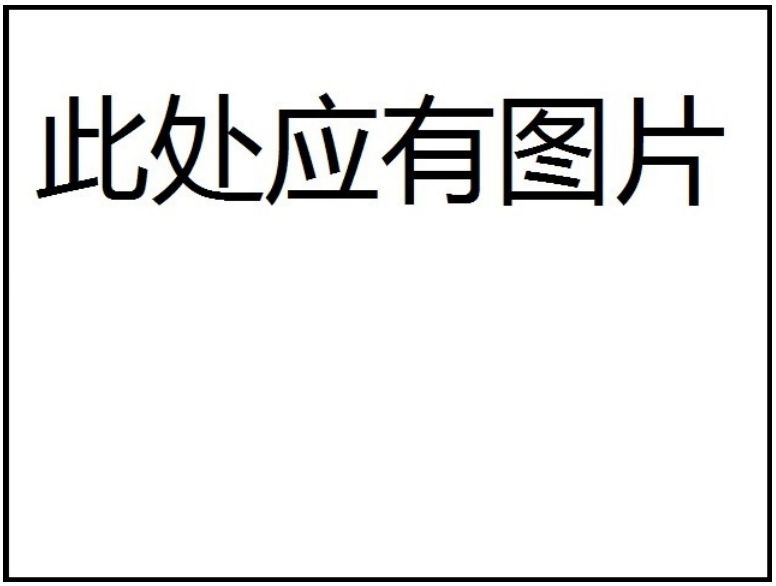

Figure 5: 1D

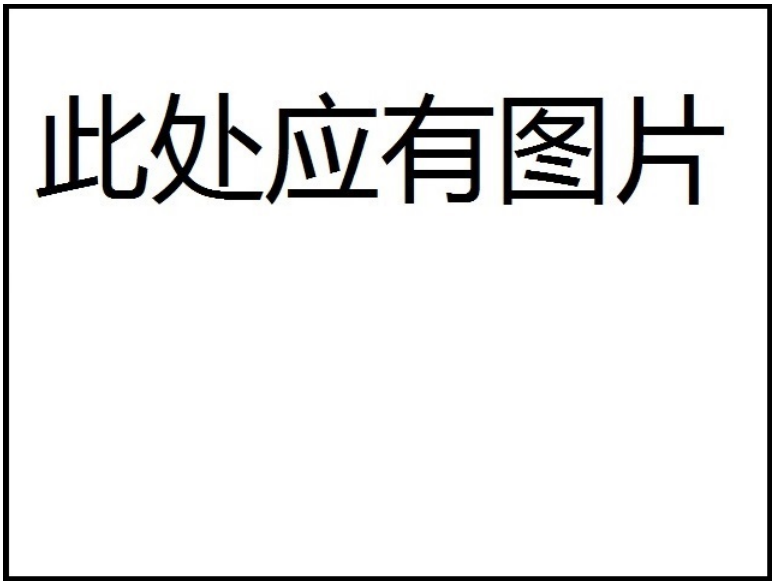

Figure 6: 2D

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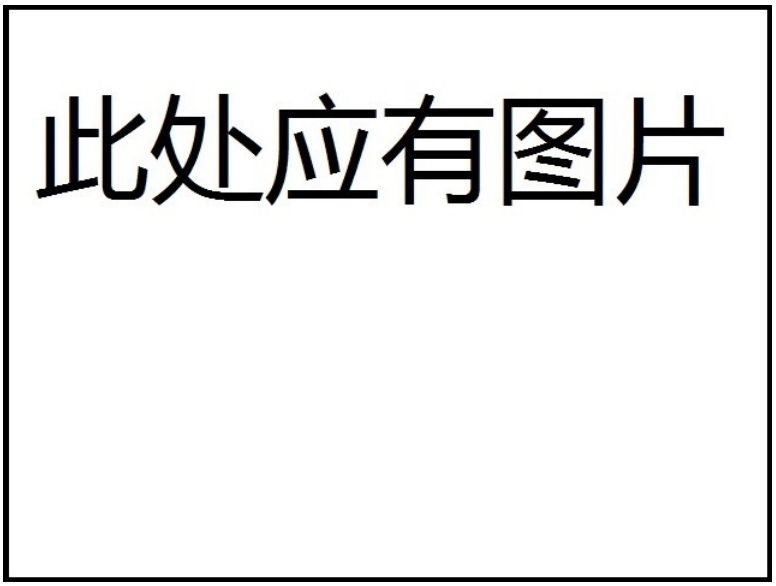

Figure 7: 3D

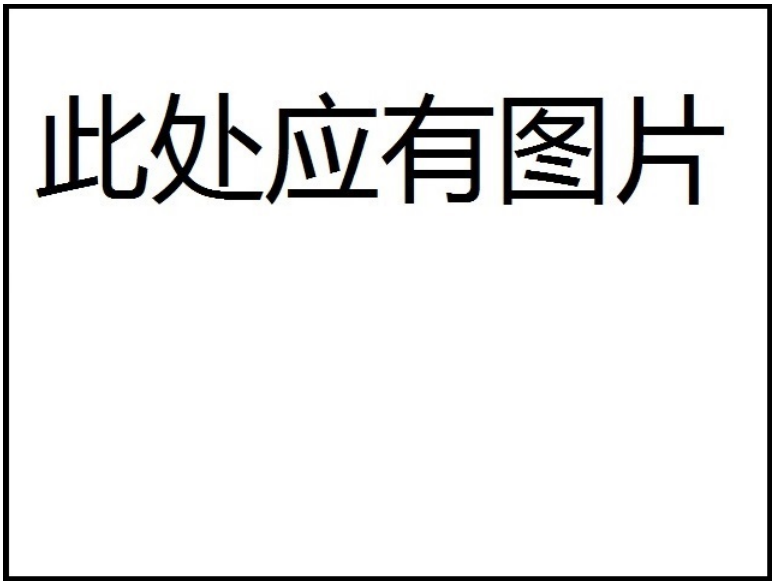

Figure 8: Curtain

3.3 Object guided

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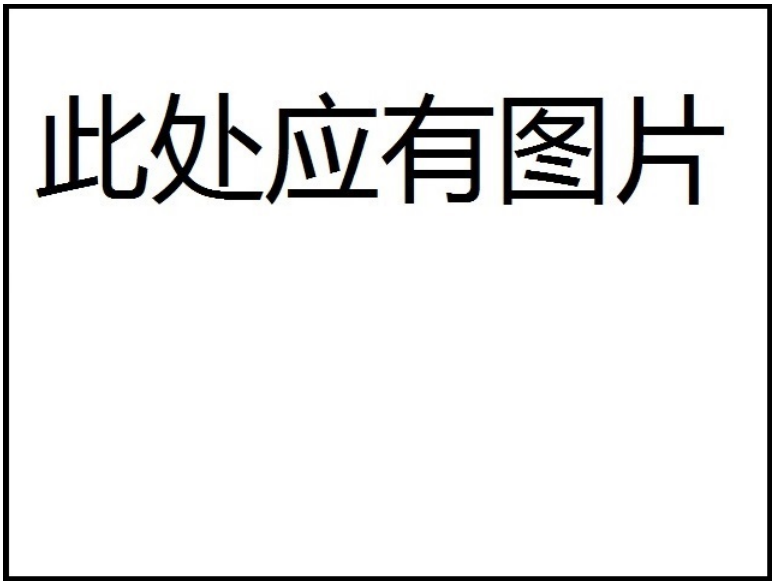

Figure 9: Objectperspective

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3.4 Vision guided

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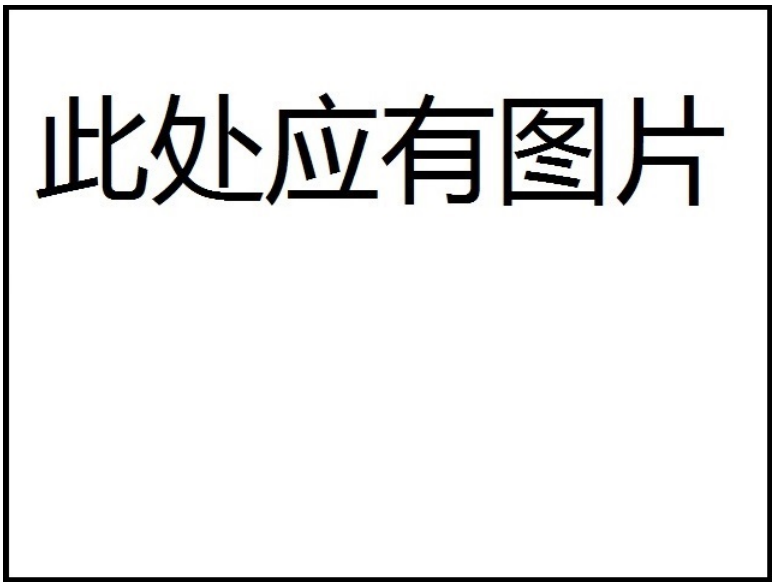

Figure 10: Perspective

3.5 Alternate plans: Ultrasonic guided

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4 Results

4.1 Introduction

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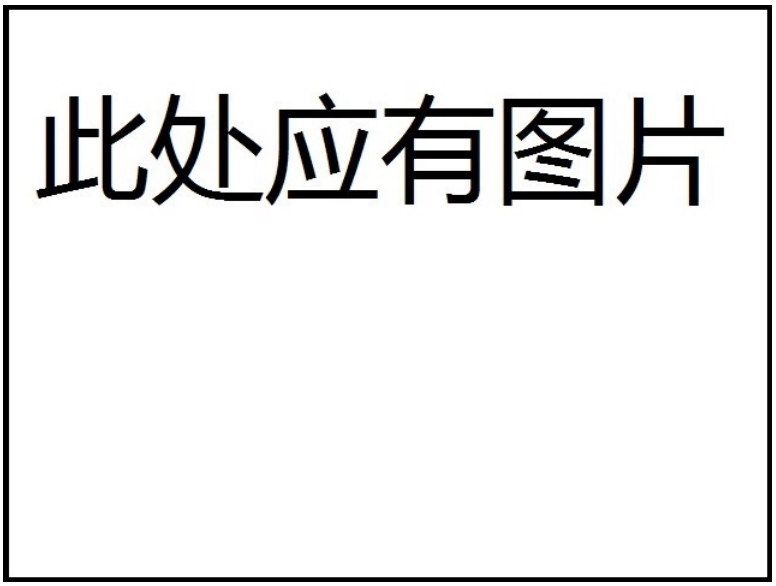

Figure 11: Twoearsdesign

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4.2 Important highlights

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4.3 Feasibility

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5 Conclusion

5.1 Importance of outdoor-AGV

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5.3 Limitations

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6 REFERENCES

References

[Bozer and Srinivasan, 1991] Bozer, Y. A. and Srinivasan, M. M. (1991). Tandem configurations for automated guided vehicle systems and the analysis of single vehicle loops. *IIE transactions*, 23(1):72–82.

[Douglas and Bencel, 2000] Douglas, B. D. and Bencel, J. A. (2000). Navigation system for automatic guided vehicle. US Patent 6,049,745.

[Egbelu and Tanchoco, 1986] Egbelu, P. J. and Tanchoco, J. (1986). Potentials for bi-directional guide-path for automated guided vehicle based systems. *International Journal of Production Research*, 24(5):1075–1097.

[Egbelu and Tanchoco, 1984] Egbelu, P. J. and Tanchoco, J. M. (1984). Characterization of automatic guided vehicle dispatching rules. *The International Journal of Production Research*, 22(3):359–374.

[Evers and Koppers, 1996] Evers, J. J. and Koppers, S. A. (1996). Automated guided vehicle traffic control at a container terminal. *Transportation Research Part A: Policy and Practice*, 30(1):21–34.

[Gaskins and TANCHOCO, 1987] Gaskins, R. and TANCHOCO, J. A. (1987). Flow path design for automated guided vehicle systems. *International Journal of Production Research*, 25(5):667–676.

[Lenain et al., 2006] Lenain, R., Thuilot, B., Cariou, C., and Martinet, P. (2006). High accuracy path tracking for vehicles in presence of sliding: Application to farm vehicle automatic guidance for agricultural tasks. *Autonomous robots*, 21(1):79–97.

[Muller, 1983] Muller, T. (1983). Automated guided vehicles.

[Vis, 2006] Vis, I. F. (2006). Survey of research in the design and control of automated guided vehicle systems. *European Journal of Operational Research*, 170(3):677–709.

[Wu and Zhou, 2004] Wu, N. and Zhou, M. (2004). Modeling and deadlock control of automated guided vehicle systems. *IEEE/ASME transactions on mechatronics*, 9(1):50–57.

A Appendix A

This is appendix A