Investigation of Stockpile-Voxel Profile and Material Reclaiming Optimization Using Bucket Wheel Reclaimer

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Thesis submitted for the degree of Doctor of Philosophy

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August 2017
 Declaration

Originality

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Dated this ......21th ........day of …August...2017
Acknowledgment

I sincerely thank Allah, the Most Gracious, the Most Merciful for giving me the inspiration, patience, time, and the ability to complete my Ph.D. successfully. With His will and mercy, I have been guided to all those great people who helped me to complete this work. In completing my Ph.D. thesis I owe a great debt to many people. I wish to extend my deep thanks gratitude and appreciation to everyone contributed to the successful.

First and foremost, I would like to express my sincere thanks, gratitude and deep appreciation to my supervisor Dr. Tien-Fu Lu for his sincere effort, interest and time he has kindly spent to guide my research. Also, I would like to extend my appreciation to co-supervisor Dr. Lei Chen for his valuable contribution to my research.

Many colleagues at the University of Adelaide have enriched my PhD experience by providing me with a good social environment, without which the ‘world’ would have been a lonelier place. I would like to give thanks to all members of the Robotics group, University of Adelaide for giving me friendly warm environment. Especially, I owe an gratitude to my colleague, Shi Zhao for much assisting works and providing necessary data for the research. My gratitude is also extended to Ben and Chris from Matrix group for giving input for the project and providing the field information.

I am grateful to Mr. Billy Constantine for his assistance on the IT support. I also would like to thank staff members of the office of the School of Mechanical Engineering for the kind support. Without the English support from Alison-jane Hunter, I am not able to complete my thesis. I would like to express my gratitude to her for the generous and prompt response whenever the help is requested. She is always ready to help.

Finally, I apologize to my family for all the sacrifices they have had to make during my candidature, and I cannot thank my wife, Thazin Naing enough for her moral support during my candidature. The inspiration received from my daughter, Khaira and my son, Zackaria plays a vital role in completing my study.

Last but not least, no words are ever sufficient to express my everlasting gratitude, appreciation and thanks to my beloved, wonderful mother and father for being the light in my life. Without their warm love, care, sincere prayers and support, it would have been impossible for me to be myself and to continue learning. My special thanks and gratitude also extend to my sister, parents-in–law and brother-in-law for their kind support and encouragement. I wish to extend my deep thanks gratitude and appreciation to everyone contributed to the successful completion of my thesis.
Publications

Journal papers


Under review

- Myo, T. R and Lu, Tien-Fu, Voxelization of stockpile into sickle-shape voxels based on bucket wheel reclaimer’s kinematics, International Journal of Mining Science and Technology.

Conference papers

Abstract

Ore producers aim to supply iron ore as close as possible to the requested specifications as blast furnaces are finely tuned to accept a particular mineral composition of ore. Besides a quality reputation, handling cost is the main concern for ore producers as iron ore is sold at a price lower than the cost of delivering garden sand. In addition, the growth in demand for iron ore and the depletion of high-grade ore resources over the years has drawn attention to improve in automation of operations. In order to fulfill the aforementioned objectives and challenges, robotics technology has been integrated into automatic mining operations over the last decade.

Generally, blending is used to compensate the short term fluctuations occurred in mining ore. However, the unavailability of assay at the blending stage has motivated researchers to focus on improving the reclaiming approach where accurate assay is available. In the literature, the cuboid voxel approach, in which stockpile is treated as a combination of virtual cuboid grids instead of being treated as a single entity, has been introduced. However, voxels are usually reclaimed using a bucket wheel reclaimer (BWR) in a circular slewing motion, which does not articulate with the cuboid shape. So the investigation is carried out on the accuracy of the reclaiming cuboid voxels by the BWR. The disparity between the cuboid voxel and the BWR reclaiming profile indicates a need to introduce an optimal voxel profile based on the BWR reclaiming profile. Hence, the sickle-shape voxel is introduced in this study, based on the BWR kinematics. Then, the stockpile is voxelized in a process through which the stockpile in Cartesian coordinate is transformed into sickle-shape voxels associated with the BWR joint parameters. The use of a single coordinate for the voxels and the BWR will reduce computational time for real time operation. A small-scaled stockpile is voxelized into sickle-shape voxels to demonstrate the process.
Besides, the quantity knowledge of the voxels is essential in voxel-based approach to identify the reclaiming voxels. So, the volume model of the sickle-shape voxel is derived in Spherical coordinate. Moreover, the volumes of voxels in the small-scaled stockpile are computed and added together to compare with the whole stockpile volume to verify the proposed volume model. Instead of using manual selection of voxels carried out in the literature, automatic identification of the optimal voxels to reclaim in order to meet the demand specifications considering the movement of the BWR is introduced. In doing that, two approaches are proposed for the minimum movement of the BWR. In the first approach, the minimum travelled distance of the BWR is taken into account to reclaim cuboid voxels in Cartesian coordinate. The objective function is defined based on Euclidean distance between voxels’ position and the BWR bucket wheel current position. The demand quality and quantity along with the reclaiming order are defined as constraints in the optimization problem. Secondly, the minimum movements of the BWR joints are considered to reclaim sickle-shape voxels. The weighting factors are assigned to each joint to prioritise the minimum movement of the high energy consumption joint. Case studies are conducted for both approaches, using Binary integer programming to solve the optimization problems. The introduction of the sickle-shape voxel approach and the automatic identification of the voxels considering the minimum movement of the BWR will improve the reclaiming accuracy required to meet the demand specifications and minimise the handling costs.
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<tr>
<td>BWR</td>
<td>Bucket wheel reclaimer</td>
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<tr>
<td>DOF</td>
<td>Degrees of freedom</td>
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<td>2-D</td>
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