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

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Declaration

Originality

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

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Publications

Journal papers

- Myo, M.T.R. and Lu, Tien-Fu, February, 2013. Investigation of the bucket wheel reclaimer's cutting trajectory to define optimal voxel shape. Transaction on Control and Mechanical Systems, 2(2): 54-60.
- Lu, Tien-Fu and Myo, M.T.R., 2010. Optimal stockpile voxel identification based on reclaimer minimum movement for target grade. International Journal of Mineral Processing, 98(1-2): 74-81.

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.
- Myo, T. R and Lu, Tien-Fu, Energy consumption optimization in reclaiming sickle-shape voxels from multiple stockpiles using bucket wheel reclaimer, International Journal of Mining, Reclamation and Environment.

Conference papers

- Myo, M.T.R. and Lu, Tien-Fu, 2013. Investigation of the Volume Calculation of Sickle-shaped Voxel of a Stockpile, 11th International Conference on Bulk Materials, Storage, Handling & Transportation (ICBMH 2013), Newcastle, Australia.
- Myo, M.T.R. and Lu, Tien-Fu, 2013. Sickle-shaped voxel approach to enhance automatic reclaiming operation using bucket wheel reclaimer, The 8th IEEE Conference on Industrial Electronics and Applications (ICIEA 2013), Melbourne, Australia, pp. 1700-1705.
- Myo, M.T.R. and Lu, Tien-Fu, 2011. The Study of BWR Cutting Trajectory for Optimal Stockpile-Voxel Profile Design, 2011 IEEE International Conference on Robotics and Biomimetics, Phuket Island, Thailand pp. 1961-1966.
- Lu, Tien-Fu. and Myo, M.T.R., 2010. Optimization of reclaiming voxels for quality grade target with reclaimer minimum movement, 11th International Conference on Control Automation Robotics & Vision (ICARCV) Singapore, pp. 341-345.

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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LIST OF ACRONYMS

BWR	Bucket wheel reclaimer
DOF	Degrees of freedom
2-D	Two dimension
3-D	Three dimension
D-H	Danevit-Hartennberg notation