博　士　論　文　の　要　約

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Studies on Tracked Dynamic Model and Optimum Harvesting Area for Path Planning of Robot Combine Harvester
(ロボットコンバインのダイナミックモデル構築と走行経路生成のための収穫領域最適化に関する研究)

Automatic path planning is an important topic nowadays for robotic agricultural vehicles. Especially for a robot combine harvester, path planning is required to choose the crop field of optimum harvesting area; otherwise, crop losses may occur during harvesting of the field. In general, a boundary zone in the field includes some water inlets and outlets, or some objects that are very dangerous for a robot running. In order to make the turning margin safe for the robot combine harvester operation, the surrounding crop near to boundary zone is cut twice or thrice by manual operation; however, this surrounding cutting crop is not exactly straight, sometimes it is curved or meandering. Developing a path planning in a conventional way, in order to take a corner position from the global positioning system by visual observation is a time consuming operation; the curved or meandering crop is not cut during harvesting, and the harvesting area is not optimum. During harvesting, this curved or meandering crop may be left in the field, which indicates the crop losses. In addition, normally, the tracked combine harvester takes turn at high speed and high steering command at the corner of the field during the cutting of outside crop nearby headland. During this turning, the inertial sensor gives the yaw rate gyro measurement bias, which is necessary to compensate for estimating absolute heading to determine the crop periphery. In order to consider the crop losses, operational processing time and compensating yaw rate gyro measurement bias, a tracked dynamic model of tracked combine harvester and optimum

harvesting area of convex or concave polygon form in the field are very important. Therefore, this research's objective is to develop a tracked combine harvester dynamic model based on the sensor measurements for estimating the absolute heading of tracked combine harvester, and an algorithm that the optimum harvesting area for a convex or concave polygon field in determining the corner vertices to calculate the working path of a robot combine harvester. A real time global positioning system and an inertial measurement unit with tracked combine harvester dynamic model are used to calculate the absolute heading in turning maneuverability, which is further used to determine the combine harvester's header end position that is called the exact outline of the remaining crop or crop periphery. Incremental convex hull method is used to estimate the convex hull from the exact outline crop position, and the optimum harvesting area and corner vertices are estimated by the rotating caliper method. However, this rotating caliper method is only suitable for a rectangular polygon field. Unlike the rotating caliper method, the developed N-polygon algorithm is applicable to all convex polygon fields. Similarly, we developed another algorithm for concave polygon fields, which is called the split of convex hull and cross point method. This method calculates the optimum harvesting area and the corner vertices from the concave polygon (like L-shape) field. The simulation and experimental results showed that our developed algorithm can estimate the optimum harvesting area and corner vertices for a convex or a concave polygon field, which takes all crop portions. Then, a path planning algorithm is used to calculate the working path based on the estimated corner vertices for the robot combine harvester, which cuts whole crop in the field during harvesting. In conclusion, the tracked combine harvester model with sensor fusion method can estimate absolute heading in course of turning maneuverability, and the estimated optimum harvesting area based on our algorithm completely reduces the crop losses, and the working path calculated based on the corner vertices requires less processing time.