Abstract

Cranes are widely used in construction, transportation and other industries due to their good capacity. There are many different types of cranes but they share the same property which is used to lift things with a hook and hoist. There are two main crane designs which are mobile crane and tower crane with a lot of different configurations. For different lifting requirements, the construction will be different in construction site. This requires the crane operator to aware of the crane's configurations, properties and limitations for safety. It means that the crane operator need to be highly trained with lots of operating experience.

For the crane working in complex construction site. Good safety and efficiency are objectives for cranes in the constantly changing working environment.As investigated, a significant of construction injuries is related to cranes. Except the requirement of operator's enough experience, to ensure the crane's operation safety, the operator need to keep keenly aware of the crane's operation properties and the working environment. It is very difficult especially for the operators with few operation experience. For the crane operator sitting in a small cabin, it is very hard for them to understand so much information about the crane and its working environment especially after a long time operation work. The accumulated mental workload of crane operator will lead to a wrong operation more easily.

Thus, providing information to assist the crane operator plays a vital role in ensuring operation safety and efficiency. The assisting information should include visual information, spatial information, navigation information and so on. To generate these information, the crane properties and spatial information of the construction site are required. The crane properties is easy to know from sensors planted in the crane. Some of the property data is displayed in load moment limiter. It is more difficult to sense the accurate spatial information of the crane's working environment.

Hence, in this thesis, the spatial information generation is our prime objective. And the crane operation assisting applications based on the generated spatial information are proposed. There are many technologies which can be used to acquire the spatial information. In this research, we make effort to acquire the spatial information of crane both from 2D and 3D based on a top-view camera. The top-view camera is mounted on the boom head of the crane and always down looking at the ground. The down looking top-view camera is used in some cranes for providing an assisting view to operator. It can help the operator obviously for the case of vision block. This is very helpful for

simple environment without many tall object in the working environment. But simply giving a vertical view of the scene is ineffective for tall objects or buildings existing in the working environment as it lacks the sense for height information. To achieve the purpose of acquiring spatial information in 2D and 3D cases, technologies associated with computer vision have been developed and applied. After acquisition of the spatial information, various information can be displayed based on the generated 2D and 3D spatial information for assisting operation.

In the 2D acquisition case, the main technology applied is image stitching. The objective is to generate a clear workspace map by stitching the images captured by the top-view camera. To achieve the objective, the foreground and background should be figured out and masked out of the captured image.

In the 3D acquisition case, the objective is to do a real-time reconstruction to generate a semi-dense 3D point cloud. This is done by combining a feature-based visual SLAM(Simultaneously Location And Mapping) method and a probabilistic depth measurement method.

The advantages of displaying assisting information based on the spatial information is obvious. Important safety information and navigation can be used to guide the operator. The hidden dangers such as collisions or out of limitations can be noticed by the operator.

In Chapter 1, the background of this research is introduced. It introduces the widely used cranes. Following this, the existing safety problem and crane operation problems are described in detail. In addition, to make the crane operation more safe and efficient, the operation assisting objectives are figured out.

In Chapter 2, a basic introduction about the technologies is made. Firstly, there is a basic introduction about image processing. Mainly 2 types of features which are used in later chapters are introduced. Alongside, a robust feature matching method is introduced. Secondly, knowledge about the optical flow is explained. In the last of this chapter, an introduction about the necessary computer vision geometry is made. The introduction is about single view and two view geometry. Specifically, it contains the relationship about how a real world object been projected to an image. And also the relationship between two images captured by a pin-hole camera at 2 close positions.

From chapter 3, the conducted research to achieve the objectives is explained in detail.

In Chapter 3, a method for segmentation of foreground and background is proposed. The 2D workspace map directly stitched from the captured images with crane's top-view camera contains obvious ghost. To generate a high quality 2D workspace map, the foreground has to be segmented and removed before image stitching. This method is mainly by comparing the two different pixels' movement which are caused differently by the 2D homography and the optical flow. Finally, experiments have been made and results are presented.

In Chapter 4, To acquire the 2D spatial information of the crane's working environment, the full pipeline which automatically generate the clear workspace map is proposed. By using the images with foreground detection and removal, the clear workspace map can be generated. With the generated 2D workspace map, applications such as locating boom head, path recording are made. Finally, an error analysis to ensure the workspace map's metric property is made.

In Chapter 5, The objective to acquire the 3D spatial information is achieved. By a combination of SVO and REMODE, a real-time system in reconstruction the 3D working environment is made. Both simulations and experiments are made to verify the system. Based on the reconstructed 3D spatial information, the application to show power limit on the image captured by the top-view camera is developed. It can help the operator recognize the safe area of operation.

Finally, in the Chapter 6, a summary of conclusions is made. Future work is discussed in detail in the last.