

Title: First Commercial Dual MeV Energy X-ray CT for Container Inspection: System, Algorithm and Results

Abstract: Container transportation is the main mode of international trade goods circulation. It is necessary and significant to check the container cargoes quickly and effectively to prevent the smuggling of goods and the invasion of toxic and hazardous goods (biological) to maintain the economic and social security of various countries. Currently, MeV energy X-ray inspection system with linear accelerator is the most effective means for Customs to quickly inspect bulk container goods. However, the existing technology can only provide X-ray perspective imaging at one or two angle-views, which may lead to false positives or false negatives due to the overlapping of different types of goods. Unfortunately, some smuggled goods or contraband goods are often hidden in other normal goods. After 6 years of research and development, the world's first commercial dual MeV energy X-ray CT inspection system for large containers was put into commercial operation in Shenzhen Customs of China in the end of 2019. This report will introduce in detail the physical calculation, system design, key algorithm, experimental results and operation of this container CT inspection system. It adopts dual 9/6MeV fast switching accelerators, dual detector arrays and a super precision rotating gantry which has a weight of 100 tons and a diameter of 13 meters. As far as the authors know, it is the largest CT gantry in the world. Its run-out errors in radial and ending directions are both limited in 2mm. A new

grid scale and encoding technique is developed to achieve the rotation positioning accuracy of 0.004° . Because there are many metal materials in container cargo, and beam-hardening and metal artifacts affect the image quality seriously, an iterative image reconstruction and material decomposition algorithm was proposed in both projection and image domains, which is also prepared with the iterative reconstruction algorithm with a Noise2Noise prior built by a deep neural network. The experimental results show that this system achieves a spatial resolution of 5mm and a contrast resolution of 4%. This talk will also show the image results of the actual containers in the Customs.