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#6-134 Augmented X-rays: New Functionalities for High energy X-rays Cargo Scanner

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Customs organizations are using since the last 90's high energies X-rays scanners as a routine inspection technic for detecting smuggling or tax fraud in trucks at terrestrial borders or in containers at ports. This technic is actually 2D radioscopy in a range of energy from 3 to 9 MeV of X-rays. The X-rays source is most of the time a linear accelerator while detection is insured by a pixellated column made of thick scintillators coupled with photodiodes. In some case, an average material discrimination information of effective atomic number is obtained by using a dual pulse (3.5 MeV/6 MeV) accelerator and a dual transmission measurement at the two energies.

This technology didn't change a lot and no other imaging functionalities than the 2D image and the discrimination information were carried out since the beginning. Through two H2020 EU projects, C-BORD (GA 653323 –H2020 BES 2014-2015) and ENTRANCE (GA 883424 –H2020 SU SEC 2019), in collaboration with more than fifteen EU partners, including six EU customs organizations, we have developed four totally new imaging functionalities which have been validated by the end-users partners during field tests. These functionalities, under the generic name Augmented X-rays, are based on the use of multi-column detectors (Matrix detector) and are in-depth information, boom movement compensation, wall removal and de-overlapping of material discrimination.

In-depth information is using the slight stereoscopic effect which occurs when scanning at low speed with a matrix detector: each column is providing with an image corresponding to a slightly different angle than the other. Usual stereoscopic methods are insufficient but with energy minimisation technics, we have demonstrated the possibility of extracting a basic depth information. This information allows to determine whether objects in cargo are located on the source side, in the middle of the cargo or on the detectors side. This was completely impossible before with single column of detectors. From end-users point of view, this functionality revealed to be instrumental for a better understanding of the content as well as for speeding up manual checking when the content of a cargo is suspicious.

Boom movement compensation is a method which allows to suppress waves artefact of mobile cargo X-rays scanner. Boom movement artefact occurs when the scan is done with a scanner moving along a steady cargo: oscillations of the boom containing the detectors during the scan are spawning waves on the image. Based on the redundancy of the information given by the different columns and using optical flows algorithmic technics, it has been demonstrated that the amplitude of the boom movement can be estimated for each pixel in the image and therefore can be corrected. In the corrected image, straight edges of objects appear as straight line and not anymore as oscillations, making it more readable for the operators.

Wall removal and de-overlap of material discrimination are two major improvements of material discrimination. As material discrimination, it is based on the used of two spectra of X-rays (typically 6/3.5 MeV, 7/4 MeV or 9/6 MeV). The method relies on the linearisation of the link between transmission measurements and thickness of the materials crossed by X-Rays thanks to a specific calibration process. As it can be done in dual energy medical radioscopy for bone or soft tissues, this new linear representation can provide with an image in which a chosen material is removed. When this material is iron, it removes from the image the wall of the containers and gives a direct view of the organic content, making easier the detection of drugs or explosives smuggling. De-overlapping of material discrimination is based on another property of the linear property and on advanced segmentation process. It allows to subtract, for each object in a cargo, all the other objects which are superimposed to it. It is then possible to get an estimation of the atomic number for each objects instead

of an average value on the whole thickness crossed by X-rays.

As it has been demonstrated in the C-BORD and ENTRANCE projects, Augmented X-rays functionalities open a new way for customs organisations in their use of high energy X-rays cargo scanner by making their operation quicker and more efficient. It is newly deployed on the new generation of cargo scanners.

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