Metal artifact reduction of computed tomography using Transformers

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1 Expose

Since the invention of computed tomography in the late 20th century, it has been possible to generate three-dimensional sectional images of bodies. For this purpose, several X-ray images of the body are taken from different angles. From the absorption values, the computer calculates the sectional images for the body.

However, metallic objects in the body such as prostheses or fillings often lead to disturbing artifacts in the form of black streaks on the images [3]. The increased number of atoms in metallic objects can lead to photon starvation, because the metal absorbs too many phontons of the X-rays. In addition, the average energy increases with increasing penetration depth of the photons, since photons with higher energy are less scattered. This effect is called beam hardening in the literature. Mathematical methods (Metal artifact reduction - MAR) like inpainting, which uses information about the surrounding pixels, can reduce artifacts to a certain extent. Other methods use the raw data of the recorded X-ray images to remove artifacts by means of forward projection. [2]

In this research project we investigate whether the artifacts described above can be reduced by a transformer network. Transformer networks were introduced in 2017 and represented a milestone for Natural Language Processing (NLP) tasks [4]. This new simple network architecture archived state of the art results and requiring significantly less time to train and they are better to parallelize than other networks. The research laboratory OpenAI presented this year a new transformer model called ImageGPT, which uses the transformer architecture to complement images [1]. The approach is an unsupervised representation learning for images where the missing pixels must be predicted by the model. This approach is promising to reduce artifacts in CBCT scans.

CBCT (cone beam computed tomography) machines take in a circular orbit a high number of 2D X-ray projections and calculate a 3D-reconstruction of the target area of the human body [3]. This results in two different data sets: the single 2D CT-scans and the 3D-volume data of the reconstruction. Therefore both datasets are used in this project to see on which data a better reduction of artifacts can be achieved. To achieve this goal, an adequate transformer model must be realized and trained on the given data. The two different datasets are split among the project participants, so that one is concerned with the reconstruction of 2D images and the other with the reconstruction of 3D volumes.

The planned approach is that the areas with artifacts are masked and then replaced by the trained model. If the reconstruction and an associated reduction of artifacts is successful, it will also be necessary to validate whether the new data is useful from a medical point of view.

References

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