Synthesizing Radiological Images with Pathologies

Master Thesis Proposal in Image Analysis and Machine Learning at the Division for Visual Information and Interaction, Department of Information Technology.

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Background

Computer-aided medical diagnosis is widely used by medical professionals to assist in the interpretation of medical images. Recently, deep learning algorithms have shown the potential to perform at higher accuracy than professionals in certain medical image understanding tasks, such as segmentation and classification. Along with accuracy, deep learning improves the efficiency of data analysis tremendously, due to its automated and computational nature. Since most medical data is produced in large volumes, and is often 3-dimensional (MRIs, CTs, etc.), it can be cumbersome and inefficient to annotate manually.

There is strong interest in computer-aided medical diagnosis systems that rely on deep learning techniques. However, due to proprietary and privacy reasons limiting data access, the development and advancement of these systems cannot be accelerated by public contributions. It is difficult for medical professionals to make most medical images public without patient consent. In addition, the publicly available datasets often lack size and expert annotations, rendering them useless for the training of data-hungry neural networks. The design of these systems is therefore done exclusively by researchers that have access to private data, limiting the growth and potential of this field of research.

Moreover, it is near impossible to collect diverse datasets that are unbiased and balanced. Most of the data used in medical imaging and other healthcare applications come from medical sites which may disproportionately serve certain specific demographics. Such datasets also tend to have very few examples of rare conditions because they naturally occur sparingly in the real world. Models trained on such biased and unbalanced datasets tend to perform poorly on test cases drawn from under-represented populations or on rare conditions. To ameliorate these issues, generative models present an intriguing alternative to fill this data void.

Aim

The aim is to develop an adaptation of the popular Pix2Pix architecture, to create synthetic 3-dimensional images (MRIs, CTs, etc.) for a pre-specified pathological condition such as brain tumor, intracranial aneurysm etc. while being able to vary its size, location and the underlying brain anatomy. We will demonstrate that the generated images are of high fidelity using objective GAN evaluation metrics. In a Human Turing test, opinion of experience radiologists will be taken such that the synthetic images are not only visually similar to real images, but also embody the respective pathological condition in radiologists' eyes. Finally, synthetic images will be used along with the real images for training deep learning based architectures and will be evaluated based on the performance gain.

Prerequisites

- Proficiency in computer programming (Python is a must).
- Extensive knowledge on deep learning environments (TensorFlow, Keras, and PyTorch) and GPU optimization.
- Background on statistical learning, parameter estimators, regression techniques, probability theory, deep learning, CNNs, GANs, VAEs.
- Experience in medical imaging physics and analysis (e.g., MRI, CT) is preferable.

References

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