

Deep learning in cardiovascular imaging

Citation for published version (APA):

Zeleznik, R. (2021). *Deep learning in cardiovascular imaging: Using A1 to improve risk predictions and optimize clinical workflows*. [Doctoral Thesis, Maastricht University]. Maastricht University. <https://doi.org/10.26481/dis.20210916rz>

Document status and date:

Published: 01/01/2021

DOI:

[10.26481/dis.20210916rz](https://doi.org/10.26481/dis.20210916rz)

Document Version:

Publisher's PDF, also known as Version of record

Please check the document version of this publication:

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Societal impact and valorizations

In this thesis, state of the art deep learning methods for medical applications were thoroughly described. The presented fully automatic CAC score estimation not only has the potential to support radiologists in their work to increase treatment efficiency and performance but could also be applied to nearly every chest CT scan taken, even if cardiac risk assessment is not the primary reason for taking the scan. For example, this system could be used to alert radiologists scanning individuals for lung cancer assessment that their patient has an increased cardiac risk and trigger a referral to cardiac specialists for follow up treatment. The presented whole heart segmentation system has shown to increase time efficiency of radiation therapy planning in a clinical workflow while maintaining segmentation accuracy and increasing overall segmentation consistency. Furthermore, these deep learning systems have shown that they are able to fast and reliably process very large cohorts of tens or hundreds of thousands of samples, which human experts would simply be unable to handle due to time constraints.

Although deep learning has shown huge success in several fields, it has yet to prove its applicability for real world applications. In recent years the number of deep learning based publications has increased dramatically but their lack of large and distinctive test cohorts often leaves the question for real world applicability and generalizability open. A further problem of medical publications is that training and test cohorts can not, or only with great efforts, be shared with the public. Additionally, sharing of trained medical models is still rare. In this thesis we focused not only on the development of novel systems but also on their real world applicability and their future impact. Therefore, we tested them in several large, independent and distinctive clinical cohorts. Furthermore, we made our full code and trained models publicly available to enable other research groups not only to replicate our results but also to test and apply our methods on data from research groups all over the world, which will further assess their applicability and hence, further enhance research and medical treatment in this field.

To share our code and the trained deep learning models we created dedicated project pages on the lab webpage at <https://aim.hms.harvard.edu>. The code is hosted and maintained at the open-source development platform www.GitHub.com. With our open source contributions we aim to have a positive impact on cardiac research and medical treatment. Coronary heart disease is still the most common cause of death in the western civilization. Early cardiac risk prediction has shown to be able to prevent future cardiac events by suggesting life-style changes. The fast automatic risk prediction makes it possible to process every recorded chest CT and assess the cardiac risk of the scanned individual. This may significantly increase the number of individuals with cardiac risk assessment and help prevent future cardiac events.

Although coronary artery calcium represents the current Gold standard for cardiac risk prediction, further advancements in cardiac risk prediction are still desired.

The heart size as well as the amount of fat within the heart are two measures with the potential to further increase the performance of cardiac risk prediction. A fully automatic implementation and application on every recorded chest CT can decrease the number of future cardiac events.