Automated Selection of Myocardial Inversion Time with a Convolutional Neural Network

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BACKGROUND

Magnetic resonance imaging (MRI) has been noted for its excellent soft tissue imaging capability with zero radiation dose. It has repeatedly been touted as the imaging modality of the future, but due to its complexity, long exam times and high cost, its growth has been severely limited. This especially has been the case for cardiac MRI, which only accounts for about I percent of all MRI exams in the United States.

Delayed enhancement (DE) imaging is an essential component of cardiac MRI, widely used for the evaluation of myocardial scar and viability. The selection of an optimal inversion time (TI), known as the myocardial null point (TINP), to suppress the background myocardial signal is required to optimize image contrast in myocardial delayed enhancement (MDE) acquisitions. Incorrect selection of TINP can impair diagnostic quality. In certain diffuse myocardial diseases such as amyloidosis, it may be difficult to identify a single optimal null point. Further, it is known that TINP varies after intravenous contrast administration, and is therefore time-sensitive.

In practice, selection of myocardial inversion time is generally performed through visual inspection and selection of TINP from an inversion recovery scout acquisition. This is dependent on the skill of a technologist or physician to select the optimal inversion time, which may not be readily available outside of specialized centers. However, such methods still rely on visual inspection of an image series by a trained human observer to select an optimal myocardial inversion time. A way to overcome these deficiencies is to embrace Deep learning approaches, including convolutional neural networks (CNNs), which have the potential to automate selection of inversion time, and are the current state-of-the-art technology for image classification, segmentation, localization, and Spatial Temporal Ensemble Myocardium Inversion NETwork (STEMI-NET) prediction. However, these static CNN models have some drawbacks which could be overcome via the use of dynamic temporal activities for object recognition.

TECHNOLOGY DESCRIPTION

Researchers at UC San Diego have developed a CNN that is capable of automated prediction of myocardial inversion time from an inversion recovery experiment. This technology is capable of automatically identifying the optimal myocardial inversion time from an inversion recovery scout acquisition. Implementation of this ensemble convolutional neural network into a clinical workflow may facilitate automation of inversion time, and may help improve the reliability and accessibility of cardiac MRI.

The researchers accomplished this through a novel transformation of an image frame selection problem into a two-class classification task. The two-class formulation enables the use of a classification approach, where otherwise selection of a single 'optimal' time frame may be too imbalanced to solve with this strategy.

APPLICATIONS

Implementation of this ensemble CNN into a clinical workflow may facilitate automation, and help improve the reliability and accessibility of cardiac MRI. This technology has the potential to be licensed or utilized by a company involved in manufacturing and sale of MR imaging equipment.

ADVANTAGES

The ensembled model utilizes spatial and temporal imaging characteristics from an inversion recovery scout to select TINP, without the aid of a human observer.

STATE OF DEVELOPMENT

With HIPAA compliance and IRB approval, the inventors retrospectively collected 425 clinically-acquired cardiac MRI exams performed 1.5T, which included inversion recovery scout acquisitions. The inventors developed a VGG19 classifier ensembled with long short term memory (LSTM) to identify TINP. 90% of the cases were used for training and 10% were used for validation. We compared the performance of the ensemble CNN in predicting TINP against ground truth, using linear regression analysis. Ground truth was defined as the expert physician-annotation of optimal inversion time.

This project is currently a working prototype for the automated TINP selection. Code has been written for data preparation, model structure, model training, and model evaluation based on the deep learning algorithms, which can predict the null point from the entire TI scout.

INTELLECTUAL PROPERTY INFO

UC San Diego is seeking non-exclusive licensees for commercializing this patent pending technology in the US.

RELATED MATERIALS

- Naeim Bahrami, Tara Retson, Kevin Blansit, Kang Wang, Albert Hsiao. Automated Selection of Myocardial Inversion Time with a Convolutional Neural Network: Spatial Temporal Ensemble Myocardium Inversion NETwork (STEMI-NET). Magn Reson Med. 2019 Feb 3.

CONTACT

University of California, San Diego
Office of Innovation and Commercialization
innovation@ucsd.edu
tel: 858.534.5815.

OTHER INFORMATION

KEYWORDS

Automation, Cardiac MRI, Convolutional Neural Network, Deep Learning, Long-short term memory (LSTM), MRI, VGG19

CATEGORIZED AS

- **Imaging**
  - Medical
- **Medical**
  - Disease: Cardiovascular and Circulatory System
  - Imaging

RELATED CASES

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PATENT STATUS

Patent Pending

University of California, San Diego
Office of Innovation and Commercialization
9500 Gilman Drive, MC 0910, ,
La Jolla,CA 92093-0910

Tel: 858.534.5815
innovation@ucsd.edu
https://innovation.ucsd.edu
Fax: 858.534.7345