University of Brasilia at Gama – FGA/UnB
Software Engineering

# Generative Adversarial Network Prior Information for Improved Compressed Sensing Magnetic Resonance Image Reconstruction

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# Resumo

A versão final do documento incluirá um resumo de todo o trabalho, incluindo metodologia, resultados e conclusão.

# Abstract

The final version of this document will include an abstract. This will summarize the introduction (contextualization, objectives, justification), the methodology, the results, and the conclusion.

## Table of Contents

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# Nomenclature and Abbreviations

**MRI** Magnetic Resonance Imaging . . . xi

**MR** Magnetic Resonance . . . xi

**ANN** Artificial Neural Networks . . . xi

**DL** Deep Learning . . . xi

**ML** Machine Learning . . . xi

**GAN** Generative Adversarial Network . . . xi

**CNN** Convolutional Neural Network . . . xii

**GPU** Graphics Processing Units . . . xi

**CV** Computer Vision . . . xi

**NLP** Natural Language Processing . . . xi

**CS** Compressed Sensing . . . xi

# 1 Introduction

In this thesis, we propose a Generative Adversarial Network (GAN) approach for prior information extraction to feed a Compressed Sensing (CS) algorithm, aiming to reconstruct images with both reduced signal-to-noise error and less acquisition time compared to conventional CS. Achieving higher quality with reduced number of samples allows faster exam procedures, making it more convenient for both patients and clinics.

## 1.1 Context

Magnetic Resonance Imaging (MRI) is a widely used imaging modality in medical practice because of its great tissue contrast capabilities, making it the best option for medical imaging when it is possible to use. MRI has evolved to the richest and most versatile biomedical imaging technique today[**?**]. However, MRI is a typically an ill-posed linear inverse task (a problem that either has no solutions in the desired class, or several solutions). The process of finding the unknown functions occurring is both time and memory consuming[1]. The information obtained from Magnetic Resonance (MR) is commonly represented by individual samples in the k-space, which is the Fourier transform of the image to be reconstructed[]. This MR sampling sparse nature makes CS a liable technique to use to reconstruct MRI.

CS has been for years the state-of-art technique in MRI and has been improved later by the use of prior information for MRI reconstruction. CS uses the premise that given a signal with a sparse representation in some known domain, it is possible to reconstruct the signal using limited linear measurements taken from a nonsparse representation.

Machine Learning (ML) methods have been utterly developed and improved recently with the use of higher computing power derived from the invention of Graphics Processing Units (GPU) and other hardware improvements, allowing Artificial Neural Networks (ANN) to come to practicality. These ANN models, often referenced as Deep Learning (DL), have become the state-of-art in various areas, from Computer Vision (CV) to Natural Language Processing (NLP). These fast paced developments led to improvements in medical data processing using DL. ML techniques can be used in several different manners to improve medical analisys, here we focus on applying GAN in the process of attaining improved prior information for CS procedure.

## 1.2 Scientific Problem Definition and Proposal

MRI is great for high quality tissue images, but there are some drawbacks: MRI exams are often very long and require the patient to be in a static position throughout the whole process, this makes the exam challenging for patients that have difficulties in keeping a still position for several minutes. Another intrinsic complication in MRI procedures is that it is nearly impossible to get images from moving tissues like a beating heart and flowing blood veins as that would require enormous amount of samples, making it practicality impossible with current technologies used in clinics. Algorithms that reconstruct MRI try to tackle this sampling issue by producing the best possible quality images for the least amount of samples collected, making the exams faster and less sample-dependent.

CS algorithms have been the state-of-art in MRI reconstruction for the past few years, and now with the advances of DL, new techniques are being produced taking advantages of how ANN are powerful in imaging processing, especially Convolutional Neural Network (CNN) and, more recently, GAN networks are becoming the new state-of-art techniques in several computer vision areas.

A problem with CS applications is that the reconstrution process can be very slow. Newer CS algorithms try to tackle this issue by adding prior information to make the algorithm abstract static information in the region analysed.

Prior information for CS can go from previous MRI frames and exams to even medical records. These prior information are normally generated by simplistic mathematical approaches like filtering and thresholding on the images. Besides the simpler technique applied, this information extraction procedures oftentimes is restricted to few frames and does not take into account the nature of organs and tissues structures, a feature that DL should be able to identify and use in order to generate better quality information. This means that there is lot of room for improvement towards prior information engineering techniques, as DL models have been proven superior in tasks of this nature.

Within this context, we propose a modern prior information engineering system with the usage of GAN, aiming for higher quality prior information to feed the CS and reducing the number of samples dependability. This will reduce the number of samples needed, making the MRI exams faster and, consequently, cheaper.

## 1.3 Objectives

#### 1.3.0.1 General Objective

### 1.3.1 Specific Objective

# 2 Theory Foundation and State-of-Art

# 3 METHODOLOGY

# 4 Results

# 5 Conclusion

# Referências Bibliográficas

[1] S. I. Kabanikhin. Definitions and examples of inverse and ill-posed problems. *Journal of Inverse and Ill-posed Problems*, 16(4), January 2008.