JILIN UNIVERSITY

PRACTICUM REPORT

Architecture Design for a Deep Learning Based Medical and Healthcare System

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Chapter1 INTRODUCTION

1.1 Deep Learning

Deep learning (also known as deep structured learning) is part of a broader family of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised. Deep learning ar-

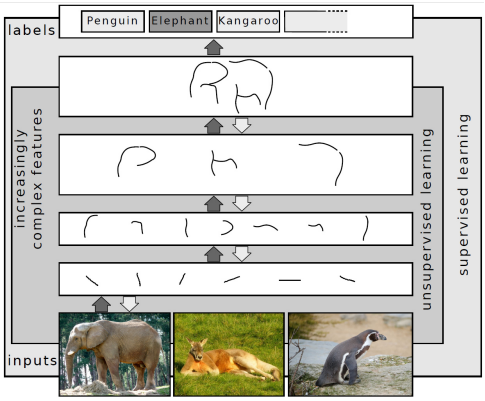


图 1.1: How Deep Learning(DL) Works

chitectures have been applied to fields including computer vision, machine vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, bioinformatics, drug design, medical image analysis, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance.[1]

1.2 Practice of DL in Medicare

Deep learning has been shown to produce competitive results in medical application such as cancer cell classification, lesion detection, organ segmentation and image enhancement.

1.3 Overview

The article reveals the main structure of a deep learning based medicare system which serves both patients and doctors well. Firstly we analyze and discuss about the requierments which is the basis of our designing. Then we collect quite a bit information to understand the business model. Finally, we shed light on our solution and give brief words introducing how it works.

[1]https://en.wikipedia.org/wiki/Deep_learning

Chapter2 Requirement Analysis

The medical and healthcare system utilizes deep learning technology in machine learning to diagnose and analyze the patient’ s condition and offer treatment plans. In this process, doctors have access to the patient’ s medical record through the digital record and the diagnosis is recorded in digital form. Then, the results of the patient’ s examinations are analyzed by the image analysis system. Doctors are able to give appropriate treatment plans considering automated diagnosis and their diagnosis and treatments are stored in the digital records in the database.

Henceforth, the main participant of the system is the doctor.

2.1 Use Case View

2.1.1 The Actor

Doctor: who is able to log in this system, have access to patients’ information, store information of the analysis and conduct an accurate analysis of illness through the image analysis program.

2.1.2 Use Case Diagram

According to the actual requirement, the doctor should be able to view and store digital records and the diagnostic results of the system-processed medical data and check and store the diagnostic results.

Then the doctor give a treatment plan.

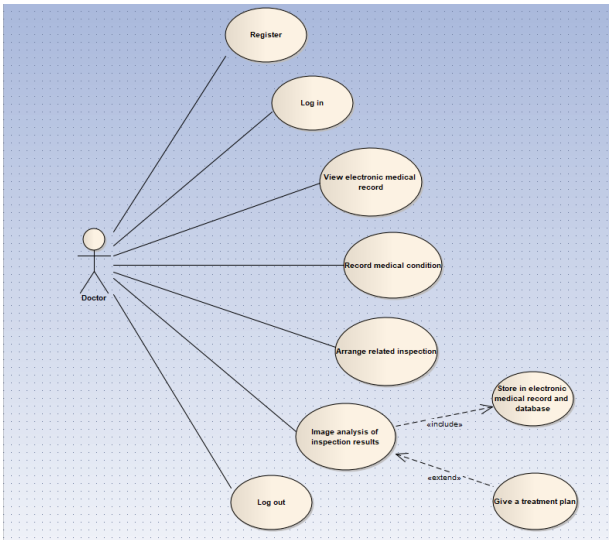


图 2.1: the Use Case Diagram

2.1.3 Specification

Use Case: Image analysis of inspection results
Participant: Doctor
Brief description: It describes how a doctor use the image analysis.
Precondition: Input the results into the image analysis program.
Main flow:

1. Doctor enter the check results as input to the program.

2. Program analyses the disease through deep learning, database comparison and other ways for the input.

3. The doctor checked the results of deep leaning algorithm's analysis and verify the diagnoses.

4. The system stores the diagnoses of doctors into database and patient's digital record.

Alternate flow:

1. Doctors accurately understand the patient's condition and give a variety of treatment strategies.

2. System sends the patient's information to relevant departments and informs them to make corresponding arrangements.

2.2 Activity Diagram (Doctor)

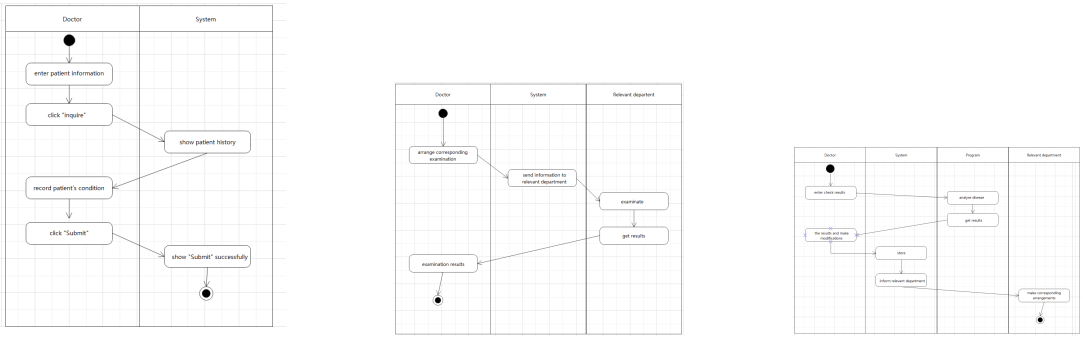
2.3 VOPC Analysis

The boundary classes include UI of record, system and program. The controller classes include register, login, department, patient and logout. The entity classes include doctor, deparment, patient. Main relationships are as follows:

1. Doctor register or login via the platform.

2. Doctor interact with department, patient via the system.

3. Doctor input the check results to program and form the diagnosis report.



(a) Viewing digital records and Recording medical condition

(b) Arranging related inspection

(c) Image Analysis of Examination Results(related department includes deep learning system)

图 2.2: Activity Diagrams

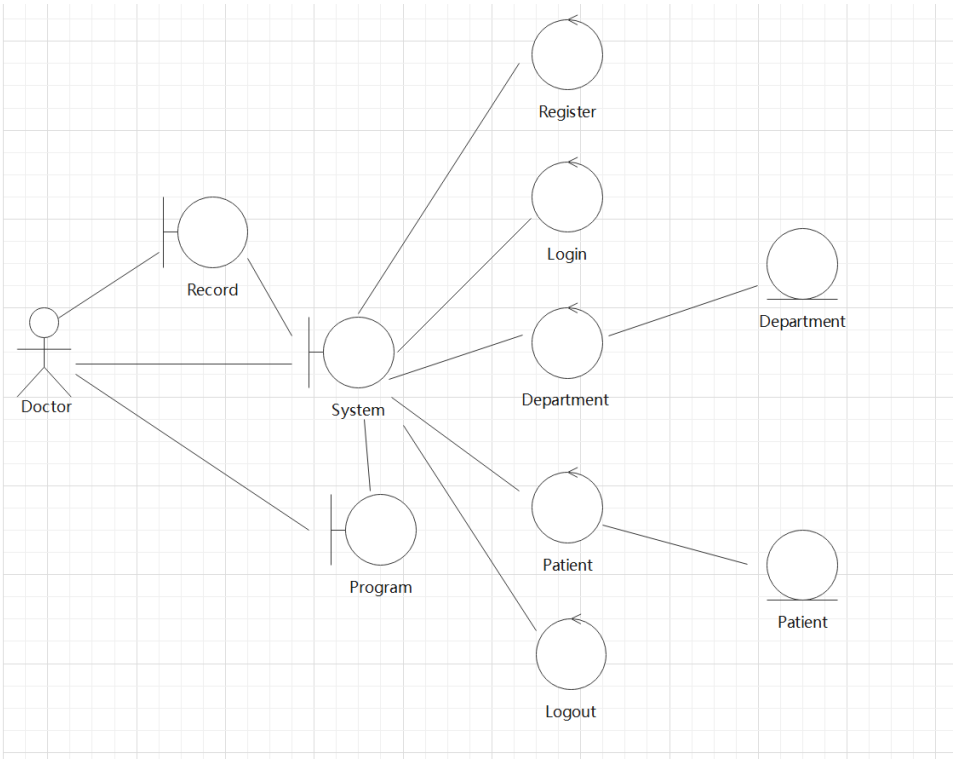


图 2.3: View of Participating Classes

Chapter3 ARCHITECTURE DESIGNING

3.1 Constraints

We defined a medical system based on deep learning that combines digital records with the patient's current situation to make medical diagnosis for the patient, and to check medical images. Hospitals can place computer machines for self-diagnosis.

After analysis, the system architecture requirements are as follows:

1. Deep learning diagnosis results and treatment recommendations can be obtained by inputting disease information, medical imaging pictures and combining with the patient's digital record.

2. This device needs to communicate data with the hospital's medical imaging machine and provide an interface for other hospital equipment for future expansion.

3. Doctors can take advantage of the system for assistance by checking medical images and to modify the recommendations given by the medical system.

4. Patient records and images can be stored in a theoretically stable database.

5. Provide two ways of accessing web pages and applications.

6. Process medical images and identify them.

7. The diagnostic accuracy of deep learning neural network can be improved with the long-term operation of the system.

The quality attributes required for the system include availability, standardization, accuracy, ease of use, maintainability, and flexibility.

3.2 Overview of Architecture

We adopt the layered architecture mode, requirements can only be passed layer by layer, can not be passed layer by layer. Layered isolation makes the layers independent of each other, with little mutual understanding between each layer in the architecture.

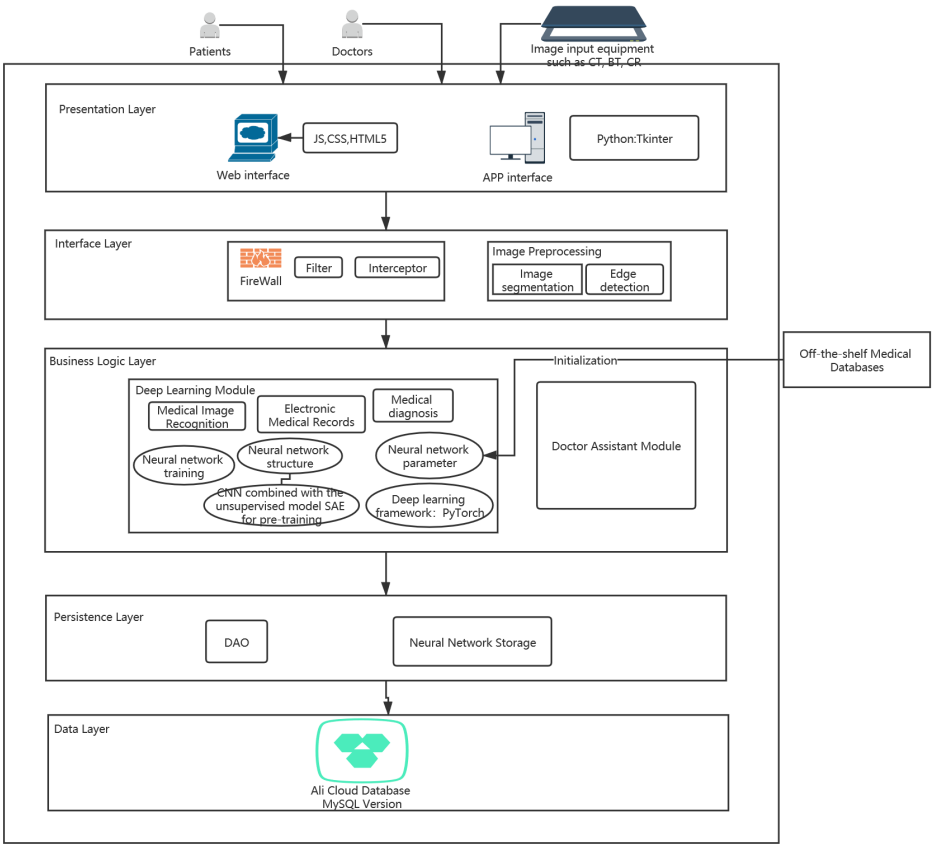


图 3.1: Hierarchy of System Architecture

3.3 Architecture in Detail

3.3.1 Persistence Layer

The persistence layer is used for the processing of data to be stored and retrieved, including electronic medical records, image information, and parameters of deep learning neural network.

3.3.2 Presentation Layer

This layer is responsible for the user interface and handles the interaction between the user and the system. The View layer in MVC.

We provide two interfaces, one through the Web browser and the other through the Windows application interface.

3.3.3 Interface Layer

This layer contains two modules. Firewall module is responsible for managing user permissions, filtering and intercepting illegal requests.

The image preprocessing module is responsible for the initial processing of medical images, such as image segmentation and edge detection. It's the Control layer in MVC.

3.3.4 Business Logic Layer

This layer includes a deep learning module and a doctor-assisted processing module. Deep learning module adopts PyTorch deep learning framework and USES convolutional neural network combined with unsupervised model SAE for pre-training. During the initial construction, the medical data in the existing database is used for initial training of the neural network and initial neural network parameters are obtained. The deep learning module consists of three sub-modules, whose functions are medical image recognition, electronic medical record, and medical diagnosis.

The doctor-assisted module allows the doctor to examine the diagnosis based on deep learning, and ultimately the doctor's opinion. Is the Model layer in MVC.

3.3.5 Data layer

The data layer deals with the storage of data and the operation of the database.

The MySQL version of Ali cloud database is selected for the database. The cloud database has low construction and maintenance costs, high concurrent processing capacity, high security and scalable capacity.

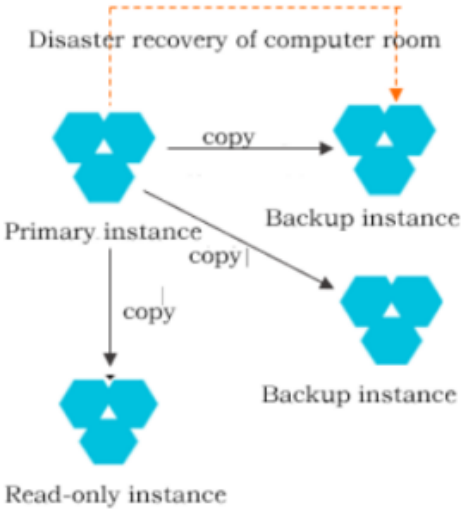


图 3.2: Database Structure

A three-node architecture with one master and two backup is adopted to ensure strong consistency of data and provide financial level reliability through synchronous replication of multiple copies.

Chapter4 Deployment

4.1 Component Diagram

Component diagram of the architecture shows the physical composition and the dependency relationship among those components of the system.

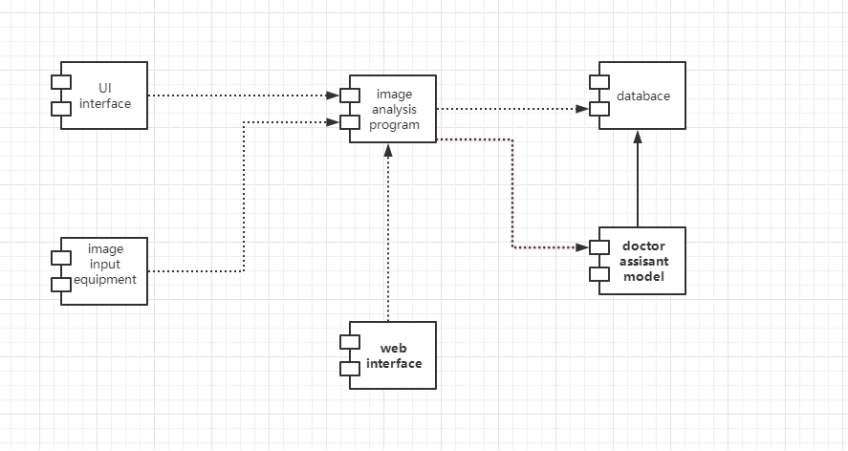


图 4.1: Component Diagram

4.2 Deployment Diagram

Deployment diagram of the architecture consists of various physical nodes for the most typical platform configurations.

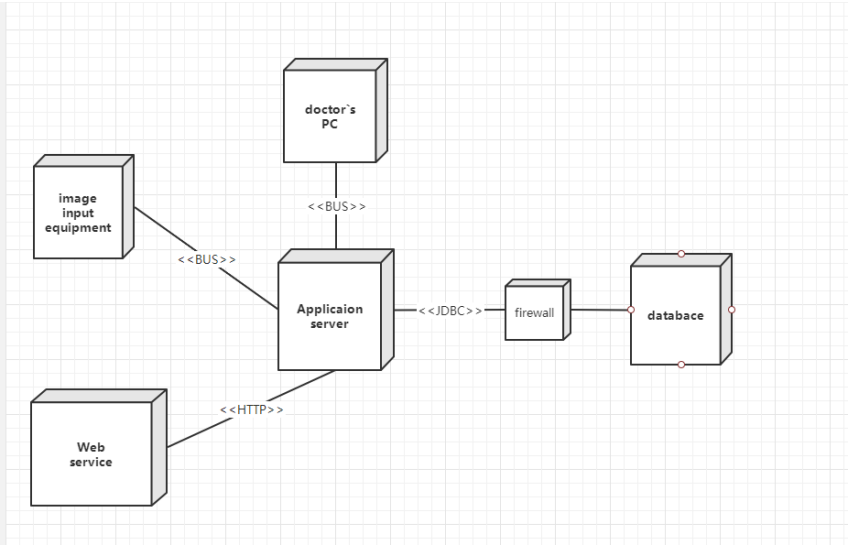


图 4.2: Deployment Diagram

The responsibilities of some crucial nodes are described as follows：

1. DoctorPC: Interacts with Application server through the bus, shows what users want to do.

2. Firewall: Protects database.

3. Database: Receives data from ApplicationServer and stores all the information.

4. Image input equipment: Collect image information of the patient.

5. Web service :Provide relevant network services.

Chapter5 Evaluation and Acknowledgement

5.1 Evaluation and Prospects

In this thesis we've showed the architecture we design which is kind of rough and lacking consideration of some accidental events.

And it takes time to make the architecture performs better in concurrency and more robust. Also, there may be some misunderstanding about the business model. It's sensible to invite people with corresponding backgroud(i.e. those who have better understanding about medicare system).

After all, we have sketched out the essential skeleton in accordance with the business model and it's enjoyable as well as challenging to put knowledge into practice.

5.2 Acknowledgement

Best regards to the staff related to this course. It takes far more efforts to keep the pace of teaching progress during this special period when COVID-19 sweeping over the world.

Reference

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