Automated Cataract Detection and Hospital Recommendation System

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Step 1: Prototype Selection

1. Problem Statement

According to the World Health Organization report, one of the world's leading causes of blindness is reported to be due to cataracts. Even though cataract majorly affects the elderly population however now they can be seen among minors too. Among the various types, the prominently three types of cataract affect masses in high numbers which are nuclear, cortical, and post-subcapsular cataract. Conventional methods of cataract diagnoses include slit lamp image tests by doctors which do not prove to be effective in classifying cataracts in the early stages and can also have inaccuracies in identifying the correct type of cataract. Therefore, there is a critical need for a reliable and automated system that can accurately detect cataracts based on clinical symptoms and recommend the nearest hospital for further evaluation and management, ultimately improving patient outcomes and reducing the burden of visual impairment caused by untreated cataracts.

2. Market/Customer/Business Need Assessment

The market needs for a reliable automated cataract detection and hospital recommendation system are driven by several key factors. Firstly, cataracts represent a significant global health concern, particularly among the elderly population, necessitating efficient diagnosis and treatment. Secondly, the lack of access to eye care services in many regions underscores the importance of solutions that can bridge this gap, offering timely interventions regardless of geographical constraints. Thirdly, the trend towards automation in healthcare aligns with the rising demand for accurate and efficient diagnostic tools. Additionally, an aging population emphasizes the urgency of early detection and management of age-related cataracts. Finally, patient-centric factors such as convenience and accessibility further underscore the need for streamlined processes in cataract detection and referral to specialized services. Addressing these market needs presents a substantial opportunity for developing an innovative system that not only meets customer expectations but also offers a competitive advantage in the healthcare landscape. By prioritizing accuracy, accessibility, and affordability, such a system can enhance patient care, driving positive outcomes, and fostering brand loyalty through improved satisfaction and referrals.

3. Viability:

1. Technological Adaptability: The system should be built on flexible and adaptable technology platforms to accommodate future advancements in medical imaging, artificial intelligence, and data analytics. This ensures that the system remains relevant and effective amidst evolving healthcare technologies.

2. Scalability and Sustainability: Scalability is crucial to accommodate increasing demand for cataract detection services due to factors such as population growth and aging demographics. Sustainable business models, incorporating factors like resource efficiency and cost-effectiveness, enable long-term viability.

3. Regulatory Compliance: Adherence to evolving regulatory standards and guidelines in healthcare is essential to ensure the system's compliance with legal and ethical requirements. This includes considerations for data privacy, patient consent, and medical device regulations.

4. Clinical Validation and Continuous Improvement: Continuous validation of the system's clinical efficacy and accuracy through rigorous testing and clinical trials is imperative. Additionally, mechanisms for incorporating feedback from healthcare professionals and patients facilitate ongoing improvements and innovation.

5. Integration with Healthcare Ecosystem: Seamless integration with existing healthcare infrastructure, including electronic health records (EHRs) and telemedicine platforms, enhances the system's interoperability and utility within the broader healthcare ecosystem.

6. Long-Term Partnerships and Collaboration: Collaborations with healthcare providers, research institutions, and industry stakeholders foster innovation and knowledge exchange, strengthening the system's position in the market and ensuring its long-term relevance.

7. Economic and Social Impact: Consideration of economic factors, such as reimbursement models and affordability, is crucial for widespread adoption and sustainability. Furthermore, addressing social determinants of health and disparities in access to healthcare services enhances the system's societal impact and long-term viability.

4. Monetization:

1. Subscription Model: Offer subscription-based access to the system, where healthcare providers or institutions pay a recurring fee for utilizing the platform. Subscription tiers can be based on usage levels, features, or the number of patients served.

2. Per-Use or Pay-Per-Patient Model: Implement a pay-per-use model where healthcare providers pay a fee for each patient's data processed or each diagnosis generated by the system. This model aligns costs with usage and can be attractive for smaller healthcare facilities.

3. Licensing Fees: License the technology to healthcare organizations, medical device manufacturers, or software companies for a fee. This model allows for broader adoption of the system across different healthcare settings and geographic regions.

4. Custom Development and Integration Services: Offer custom development and integration services to tailor the system to specific healthcare providers' needs or integrate it with existing electronic health record (EHR) systems. Charge fees for consulting, customization, and integration services.

5. Value-Added Features: Introduce premium features or add-ons, such as advanced analytics, predictive modeling, or telemedicine integration, and monetize them separately. This allows for additional revenue streams while catering to specific customer needs.

6. Training and Support Services: Provide training, implementation support, and ongoing technical assistance to healthcare professionals using the system. Charge fees for training workshops, certification programs, and premium support services.

7. Partnerships and Collaborations: Form partnerships with pharmaceutical companies, medical device manufacturers, or insurance providers to offer complementary services or leverage their networks for distribution. Explore revenue-sharing agreements or referral fees.

Step 2: Prototype Development

CODE IMPLEMENTATION (SMALL SCALE):

Github: https://github.com/Pacchu04/Feynn-Labs/tree/main/Project-3%20Cataract%20Detection%20System

Let's import the dataset

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import cv2
import random
from tqdm import tqdm
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

Loading Dataset:

```
df = pd.read_excel("/content/ODIR-5K/ODIR-5K/data.xlsx")
df.head(3)
```

Creating Model:

ImageNet Model:

```
from tensorflow.keras.applications.vgg19 import VGG19
vgg = VGG19(weights="imagenet",include_top = False,input_shape=(image_size,image_size,3))
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg19/vgg19_weights_tf_dim_order
80134624/80134624 [==============================] - 1s 0us/step
```

```
for layer in vgg.layers:
    layer.trainable = False
```

```
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Flatten,Dense
model = Sequential()
model.add(vgg)
model.add(Flatten())
model.add(Dense(1,activation="sigmoid"))
```

```
model.summary()
```

Vgg19 Model:

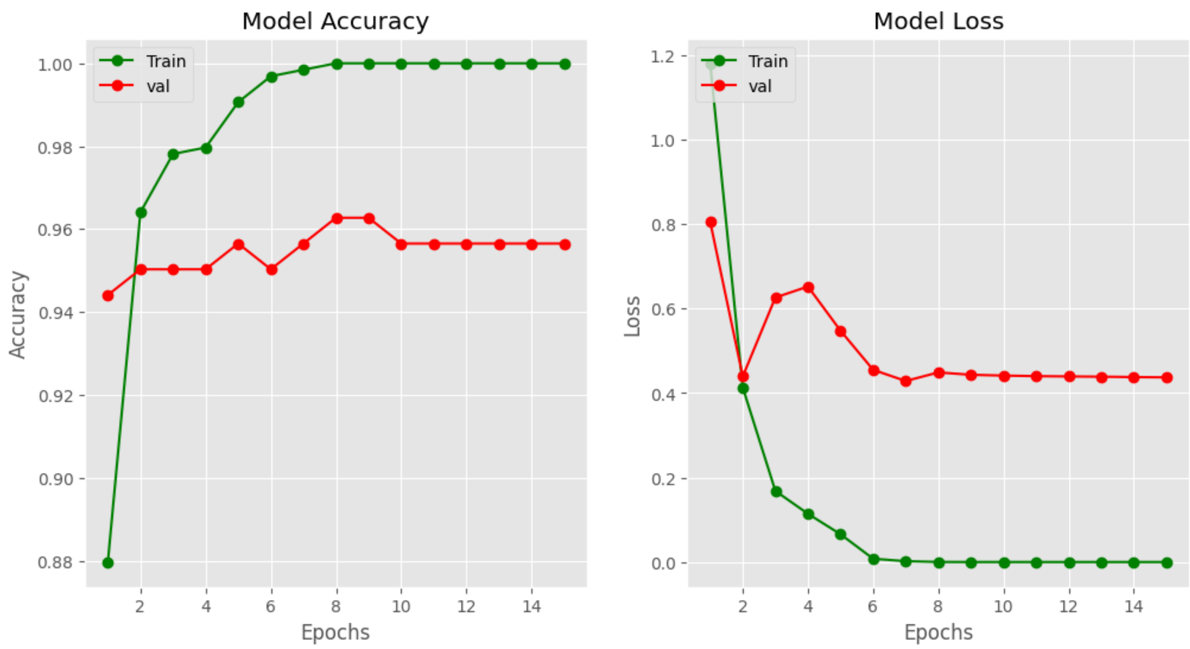
```
model.compile(optimizer="adam",loss="binary_crossentropy",metrics=["accuracy"])
```

```
from tensorflow.keras.callbacks import ModelCheckpoint,EarlyStopping
checkpoint = ModelCheckpoint("vgg19.h5",monitor="val_acc",verbose=1,save_best_only=True,
                             save_weights_only=False,period=1)
earlystop = EarlyStopping(monitor="val_acc",patience=5,verbose=1)
```

```
WARNING:tensorflow:`period` argument is deprecated. Please use `save_freq` to specify the frequency in number o
```

```
history = model.fit(x_train,y_train,batch_size=32,epochs=15,validation_data=(x_test,y_test),
                    verbose=1,callbacks=[checkpoint,earlystop])
```

Model Performance:



Step 3: Business Modelling

Proposed System

Project is divided into two phases. First phase aims to detect the presence of cataract, if cataract is present then the second phase classifies the type of cataract on the severity level: normal, mild and severe. The following steps are involved in designing and training the model.

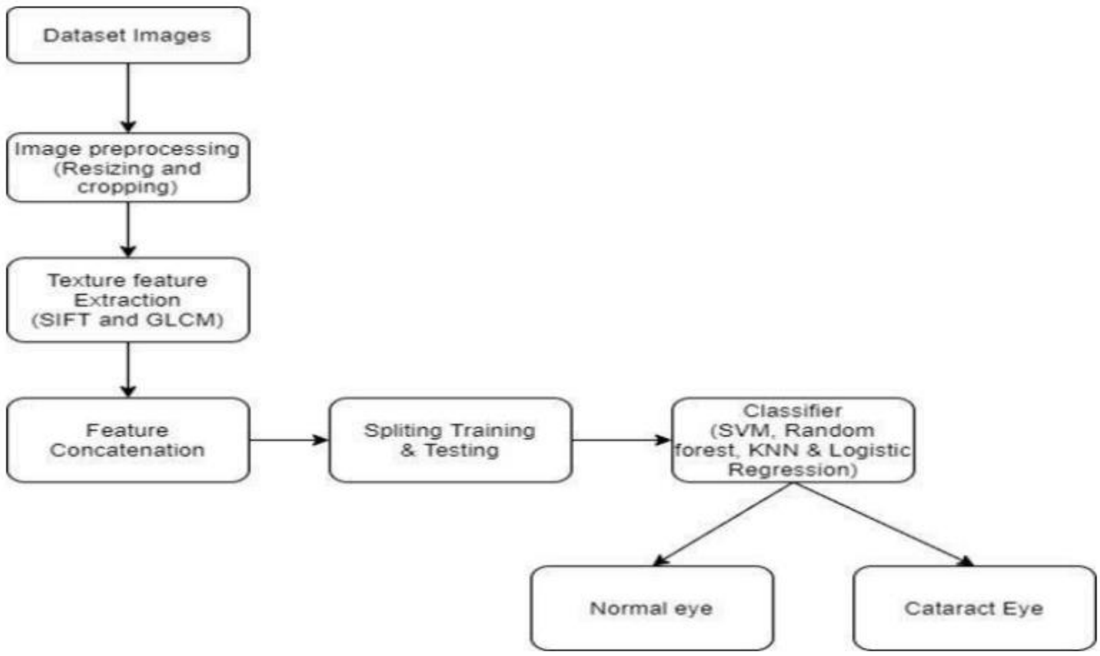
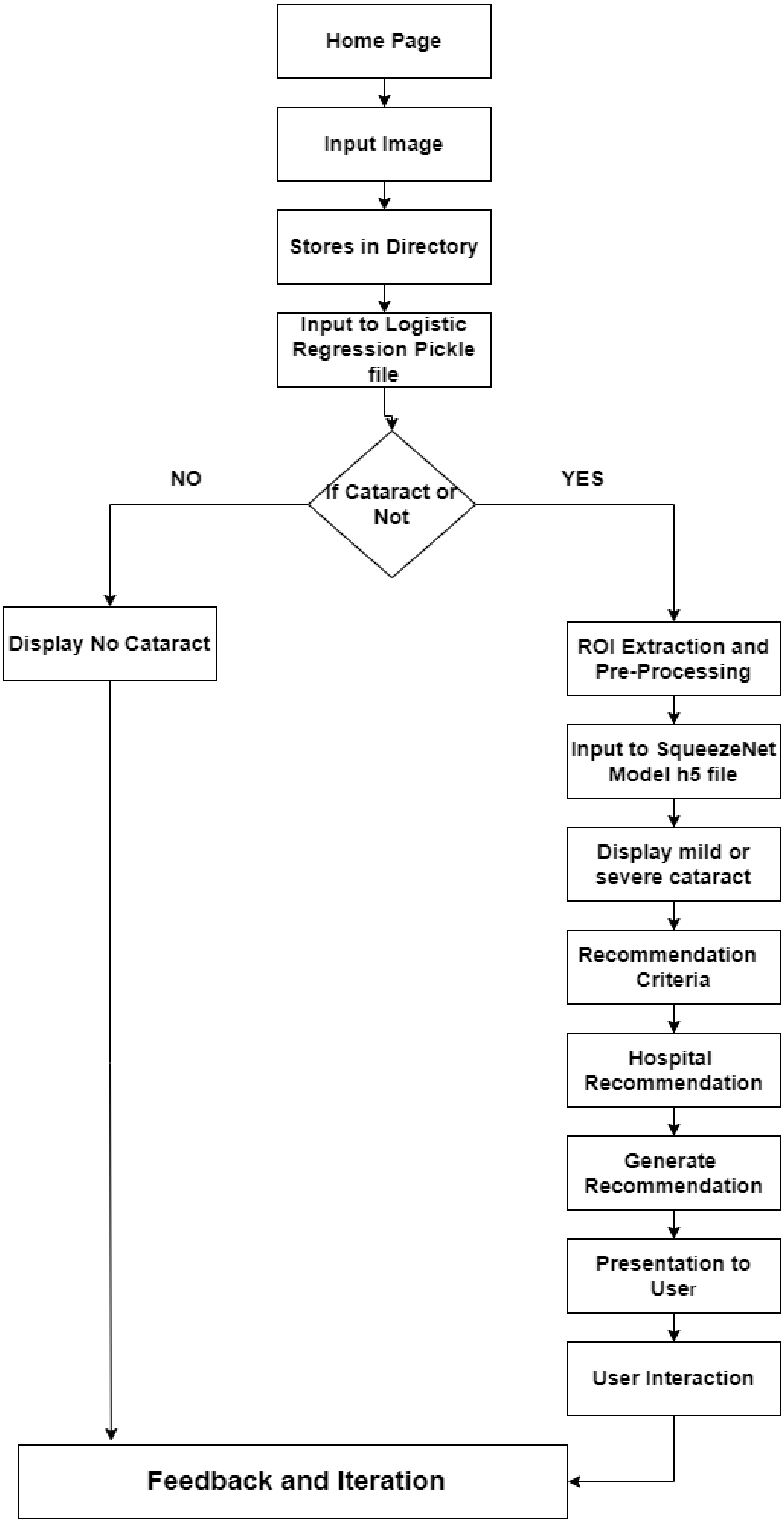


Fig 1. Data Flow binary classification

FINAL PRODUCT PROTOTYPE



Step 4: Financial Modelling

-Identify which Market your product/service will be launched into

1. Healthcare Providers:

- Hospitals: Large hospitals and medical centers that offer comprehensive eye care services would be primary targets. These facilities often handle a significant volume of cataract cases and would benefit from AI-powered tools to streamline diagnosis and referral processes.

- Clinics and Eye Care Centers: Specialty clinics and eye care centers focused on ophthalmology would also be key customers. These facilities may have specialized expertise in treating eye conditions and could leverage AI technology to enhance their diagnostic capabilities.

2. Healthcare Professionals:

- Ophthalmologists: Eye care specialists responsible for diagnosing and treating cataracts would be direct users of the AI service. They would rely on the system to assist in accurate diagnosis, patient management, and referral to appropriate treatment facilities.

- Optometrists: Optometric professionals involved in primary eye care may also benefit from the AI service, particularly in cases where cataracts are detected during routine eye exams.

3. Patients:

- Individuals with Cataracts: Patients experiencing symptoms of cataracts or at risk of developing them would be indirect beneficiaries of the AI service. Early detection facilitated by the system could lead to timely intervention and improved outcomes, preserving vision and quality of life.

- Caregivers and Family Members: Family members or caregivers of individuals with cataracts may also play a role in the decision-making process regarding diagnosis and treatment options. They could advocate for the adoption of AI technology to support healthcare providers in delivering quality care.

4. Healthcare Technology Companies:

- Medical Device Manufacturers: Companies specializing in medical imaging equipment, diagnostic devices, and AI technology for healthcare applications could be potential collaborators or partners in bringing the AI service to market. Integration with existing medical devices and platforms may enhance the value proposition of the service.

5. Healthcare Payers:

- Insurance Companies and Payers: Insurers and healthcare payers may have an interest in the AI service if it demonstrates cost savings, improved patient outcomes, and reduced healthcare utilization related to cataract diagnosis and treatment. Reimbursement policies and coverage for AI-enabled services would influence adoption by healthcare providers and patients.

Financial Equations

Assumptions:

- Price of the product (m): ₹5,000 per cataract detection service

- Total Sale as a Function of Time (x(t)): Depends on market demand

- Total Production and Maintenance Cost (c): ₹600,000 (including team cost, server costs, software costs, office/fiber costs, etc.)

Financial Equation:

- Total Profit (y) = Price of the product (m) * Total Sale as a Function of Time (x(t)) - Total Production and Maintenance Cost (c)

Given that x(t) depends on market demand and may vary over time, we'll need to estimate or forecast the total sale based on market trends, user demand, marketing efforts, etc.

Let's say we estimate the total sale (x) to be 1,000 cataract detection services over a certain period (t), and we'll use the provided financial equation to calculate the total profit (y).

Financial Calculation:

- Total Sale (x) = 1,000 cataract detection services

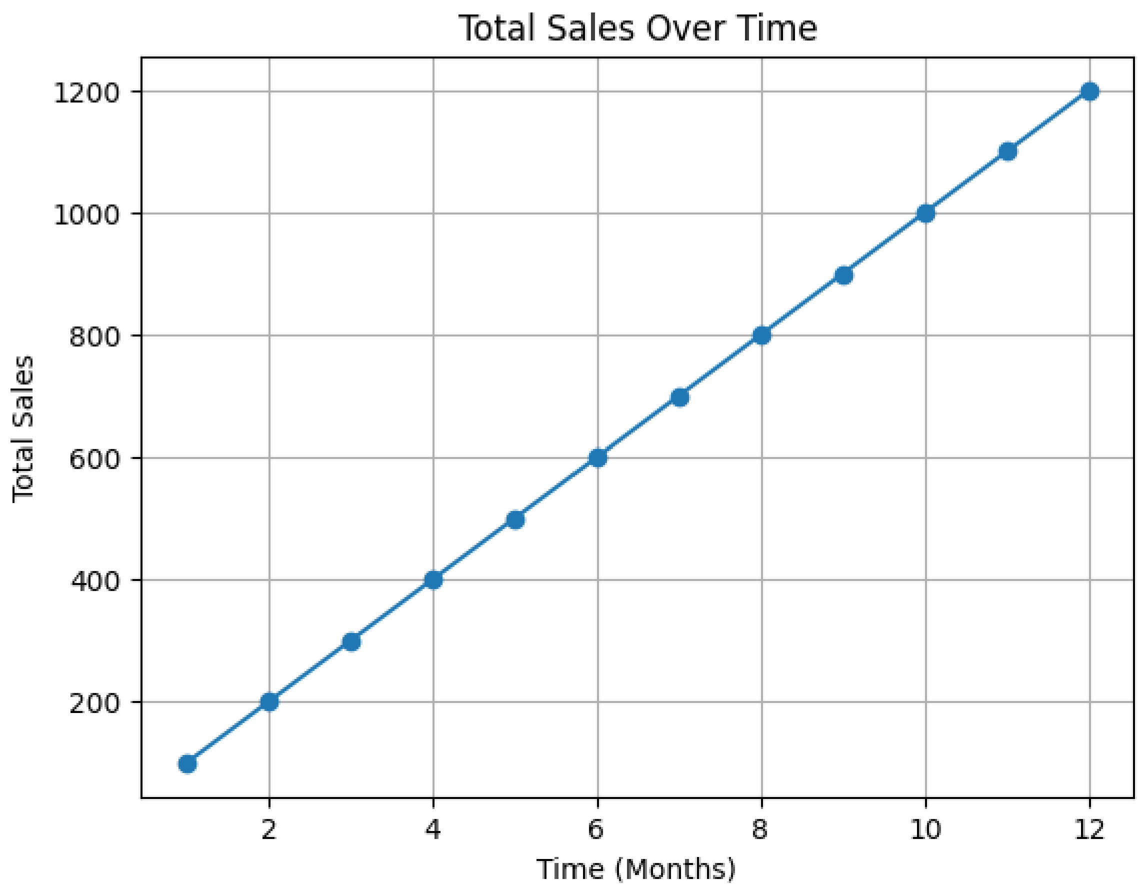
- Total Production and Maintenance Cost (c) = ₹600,000

Using the financial equation:

- Total Profit (y) = ₹5,000 * 1,000 - ₹600,000

- Total Profit (y) = ₹5,000,000 - ₹600,000

- Total Profit (y) = ₹4,400,000



So, the estimated total profit for the automated cataract detection and hospital recommendation system is ₹4,400,000.

GitHub Link: https://github.com/Pacchu04/Feynn-Labs/tree/main/Project-3%20Cataract%20Detection%20System