Basic Design Document (BDD) – Distributed Imaging System

1. Overview

This system is designed to process images in a distributed manner using three C++ applications (image-generator, feature-extractor, data-logger), RabbitMQ as a message broker, and PostgreSQL as a storage backend. The architecture ensures reliable and continuous image processing with support for large images.

Objectives:

- Continuous ingestion and delivery of images.
- Feature extraction using OpenCV (SIFT).
- Reliable storage of processed results in a database.
- Cross-platform support and Dockerized deployment.

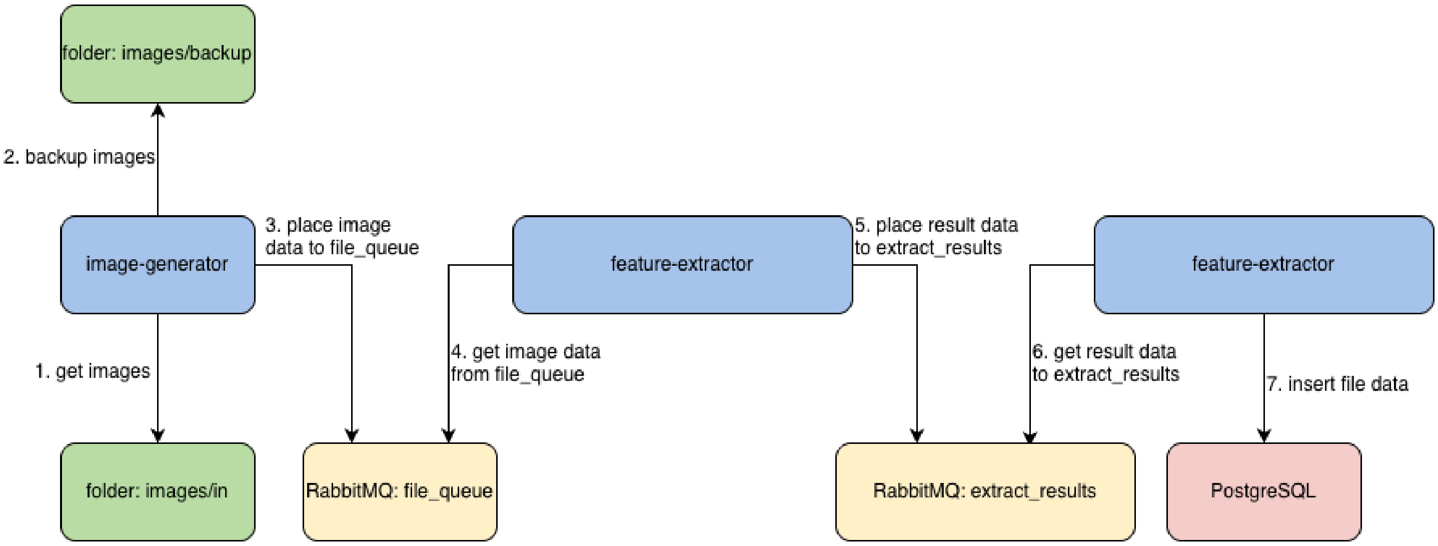
2. System Architecture

2.1 Components

- image-generator – Image Generator / Publisher
  - Reads images from image/in folder.
  - Adds date/time prefix and stores backups in image/backup/YYYY/MM.
  - Publishes images as binary data to RabbitMQ queue file_queue.
  - Deletes files after successful publishing.
- feature-extractor – Feature Extractor
  - Listens on RabbitMQ queue file_queue.
  - Receives image data and metadata (filename, backup path).
  - Uses OpenCV SIFT to extract keypoints.
  - Publishes JSON results containing image metadata and keypoints to RabbitMQ queue extract_results.
- data-logger – Data Logger
  - Listens on RabbitMQ queue extract_results.
  - Persists JSON data into PostgreSQL database (voyis_main) table files.
  - Supports large JSON payloads and concurrent inserts.
- RabbitMQ
  - Message broker for inter-process communication.
  - Queues:
    - file_queue → images from image-generator to feature-extractor.
    - extract_results → processed SIFT results from feature-extractor to data-logger.

- PostgreSQL
  - Database to store image metadata and SIFT results.
  - Table files schema:
  - CREATE TABLE files (
  - id SERIAL PRIMARY KEY,
  - filename VARCHAR(100) NOT NULL,
  - backup_path VARCHAR(255) NOT NULL,
  - json_data JSONB NOT NULL,
  - created_at TIMESTAMPTZ NOT NULL DEFAULT NOW()
  -);

2.2 High-Level Flow


folder: images/backup
2. backup images
image-generator
3. place image data to file_queue
feature-extractor
5. place result data to extract_results
feature-extractor
1. get images
4. get image data from file_queue
6. get result data to extract_results
7. insert file data
folder: images/in
RabbitMQ: file_queue
RabbitMQ: extract_results
PostgreSQL

2.3 Docker Deployment

- Base Image: my-base-image with OpenCV, Boost, SimpleAmqpClient, and build tools.
- Services (docker-compose):
  - rabbitmq
  - postgres
  - cpp-image-generator-app (image-generator)
  - cpp-feature-extractor-app (feature-extractor)
  - cpp-data-logger-app (data-logger)
- Volumes:
  - ./images:/images → share host image folder with image-generator
  - postgres_data:/var/lib/postgresql/data → persist DB

3. Design Decisions

- IPC Mechanism: RabbitMQ for reliable asynchronous communication.
- Backup Strategy: Images stored under backup/YYYY/MM with timestamped filenames.
- Continuous Loop: image-generator keeps sending images in a loop; supports images of varying sizes (KB → 30MB+).
- Error Handling:
    - feature-extractor skips corrupted or empty images.
    - data-logger validates JSON before DB insert.

4. Technology Stack

Component	Technology / Library
Programming	C++17
Image Processing	OpenCV (SIFT)
Messaging	RabbitMQ, SimpleAmqpClient
Database	PostgreSQL
JSON Handling	nlohmann/json
Build & Packaging	Docker, g++

5. Folder Structure

```
project-root/

├──── image-generator/

    ├──── Dockerfile

    ├──── main.cpp

├──── feature-extractor/

    ├──── Dockerfile

    └──── main.cpp

├──── data-logger/

    ├──── Dockerfile

    └──── main.cpp

├──── db/

  └──── init.sql

├──── Dockerfile.base

├──── docker-compose.yml

└──── images/

    ├──── in/

    └──── backup/
```

6. Future Enhancements

- Support multiple image formats dynamically.
- Add retry and dead-letter queue for failed messages.
- Add monitoring for queue sizes and processing latency.
- Optional GPU acceleration for feature extraction.
- Web interface for visualizing processed images and keypoints.

7. References

- OpenCV documentation: https://docs.opencv.org
- SimpleAmqpClient: https://github.com/alanxz/SimpleAmqpClient
- RabbitMQ: https://www.rabbitmq.com/
- PostgreSQL: https://www.postgresql.org/