CSCI 4370 Term Project

Initial Steps

Title

Lunar Reconnaissance Orbiter (LRO) Image Storage and Interfacing

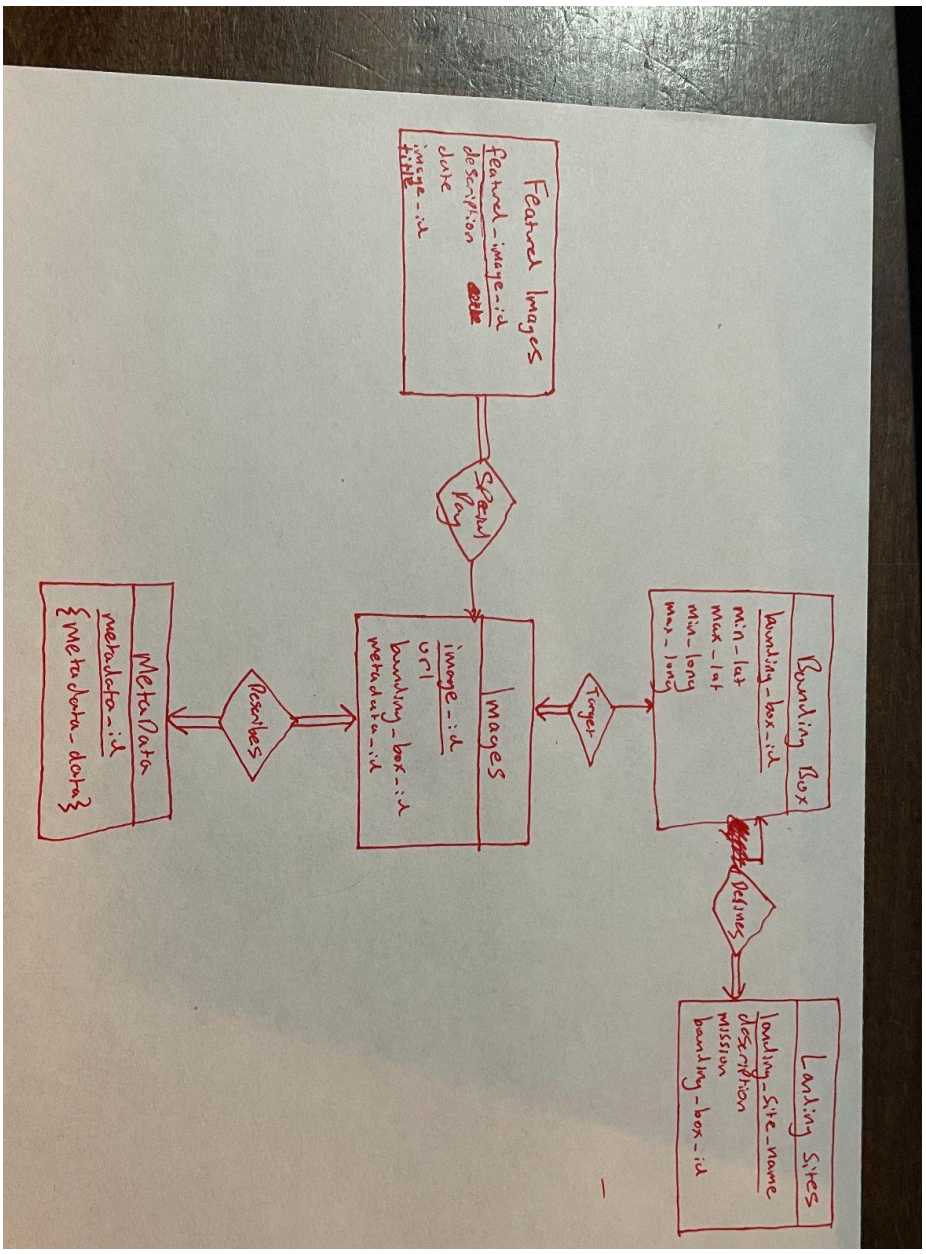
Problem Description

The LRO satellite is a NASA spacecraft that has been orbiting the Moon since its launch in 2009. The mission of LRO was to capture images of the surface and reconstruct them into 3-D maps at 100-meter resolution. This mission was accomplished, as LRO has constructed these maps for upwards of 98% of the Moon's surface. An issue arises when thinking about the storage of these images and their associated metadata. Users should be able to access data regarding images, targets (craters), metadata, and other information associated with the data products produced by the mapping mission.

Solution Description and User Interfaces

Our solution to the issue is to create a web application that will allow users to view all images and craters, as well as individual images and craters. In this individual view more in depth information will be available, and users will have the ability to create their own datasets. Datasets will include images, craters, their bounding boxes, and metadata associated with images. There will also be a functionality that shows featured images, which are on a daily basis.

Preliminary ER Diagram



Technologies Used

Java, Spring Boot, JDBC connection, Docker (MySQL), Maven

Database Design

ER to Table Conversion

The initial ER model was created based on our conceptual understanding and desire for how the project would function in support of the listed requirements. The conversion process was completed using the rules outlined in the course lecture notes, resulting in the tables below.

- Images and MetaData are one to one as well as total. Following the ER to table conversion rules, they are to be combined.
- Bounding_Box_id was added as fk in LandingSites since LandingSites and BoundingBox share a one-one relationship which is total on the LandingSites side.
    - Image_id would have been added as a <fk> to FeaturedImage if it was not already there.

Images(image_id <pk>, url, bounding_box_id <fk>, metadata_data)
BoundingBox(bounding_box_id <pk>, min_lat, max_lat, min_long, max_long)
LandingSites(landing_site_name <fk>, LS_description, mission, bounding_box<fk>)
FeaturedImages(featured_image_id <pk>, FI_description, date, image_id <fk>)

The functional dependencies listed below were also generated from the ER diagram and were used for normalizing the database schema to 3NF form.

F = {

Image_id -> url, bounding_box_id, metadata_data
Bounding_box_id -> min_lat, max_lat, min_long, max_long
Landing_site_name -> LS_description, mission, bounding_box_id
Featured_image_id -> FI_description, date, image_id, title

}

Normalizing to 3NF Form

3NF Synthesis

The 3NF synthesis was performed using the procedures outlined in the course lecture notes. It consists of five total steps:

1. Find minimal basis
2. Merge FDs in minimal basis with same LHS
3. Form table for each FD
4. Remove tables that are subsets of another
5. Ensure at least one table contains the global key

Minimal Basis

Finding the minimal basis of the FDs acquired from the ER model was done following the procedures outlined in the course lecture notes. It consists of three parts:

1. Split RHS of each FD

2. Removing attributes from LHS of each FD, as possible
3. Remove FDs, as possible

Splitting FD RHS

F = {
    Image_id -> url
    Image_id -> bounding_box_id
    Image_id -> metadata_data
    Bounding_box_id -> min_lat
    Bounding_box_id -> max_lat
    Bounding_box_id -> min_long
    Bounding_box_id -> max_long
    Landing_site_name -> LS_description
    Landing_site_name -> mission
    Landing_site_name -> bounding_box_id
    Featured_image_id -> FI_description
    Featured_image_id -> date
    Featured_image_id -> image_id
    Featured_image_id -> title
}

Removing attributes from LHS

All FDs currently in F have single LHS attribute, cannot remove attributes.

Removing FDs

Trying image_id -> url

F = {
    Image_id -> bounding_box_id
    Image_id -> metadata_data
    Bounding_box_id -> min_lat
    Bounding_box_id -> max_lat
    Bounding_box_id -> min_long
    Bounding_box_id -> max_long
    Landing_site_name -> LS_description
    Landing_site_name -> mission
    Landing_site_name -> bounding_box_id
    Featured_image_id -> FI_description
    Featured_image_id -> date
    Featured_image_id -> image_id
    Featured_image_id -> title
}

Url cannot be inferred from F - {image_id -> url}, so FD cannot be removed.

Trying image_id -> bounding_box_id

F = {
	Image_id -> url
	Image_id -> metadata_data
	Bounding_box_id -> min_lat
	Bounding_box_id -> max_lat
	Bounding_box_id -> min_long
	Bounding_box_id -> max_long
	Landing_site_name -> LS_description
	Landing_site_name -> mission
	Landing_site_name -> bounding_box_id
	Featured_image_id -> FI_description
	Featured_image_id -> date
	Featured_image_id -> image_id
	Featured_image_id -> title
}

Bounding_box_id cannot be inferred from F - {image_id -> bounding_box_id}, so cannot remove FD.

Trying image_id -> metadata_data

F = {
	Image_id -> url
	Image_id -> bounding_box_id
	Bounding_box_id -> min_lat
	Bounding_box_id -> max_lat
	Bounding_box_id -> min_long
	Bounding_box_id -> max_long
	Landing_site_name -> LS_description
	Landing_site_name -> mission
	Landing_site_name -> bounding_box_id
	Featured_image_id -> FI_description
	Featured_image_id -> date
	Featured_image_id -> image_id
	Featured_image_id -> title
}

Metadata_data cannot be inferred from F - {image_id -> metadata_data}, so cannot remove FD.

Trying bounding_box_id -> min_lat

F = {

	Image_id -> url
	Image_id -> bounding_box_id

Image_id -> metadata_data
Bounding_box_id -> max_lat
Bounding_box_id -> min_long
Bounding_box_id -> max_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> FI_description
Featured_image_id -> date
Featured_image_id -> image_id
Featured_image_id -> title
}

Min_lat cannot be inferred from F - {bounding_box_id -> min_lat}, so cannot remove FD.

Trying bounding_box_id -> max_lat

F = {
Image_id -> url
Image_id -> bounding_box_id
Image_id -> metadata_data
Bounding_box_id -> min_lat
Bounding_box_id -> min_long
Bounding_box_id -> max_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> FI_description
Featured_image_id -> date
Featured_image_id -> image_id
Featured_image_id -> title
}

Max_lat cannot be inferred from F - {bounding_box_id -> max_lat}, so cannot remove FD.

Trying bounding_box_id -> min_long

F = {
Image_id -> url
Image_id -> bounding_box_id
Image_id -> metadata_data
Bounding_box_id -> min_lat
Bounding_box_id -> max_lat
Bounding_box_id -> max_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> FI_description

Featured_image_id -> date
Featured_image_id -> image_id
Featured_image_id -> title
}

min_long cannot be inferred from F - {bounding_box_id -> min_long}, so cannot remove FD.

Trying bounding_box_id -> max_long

F = {
Image_id -> url
Image_id -> bounding_box_id
Image_id -> metadata_data
Bounding_box_id -> min_lat
Bounding_box_id -> max_lat
Bounding_box_id -> min_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> FI_description
Featured_image_id -> date
Featured_image_id -> image_id
Featured_image_id -> title
}

min_long cannot be inferred from F - {bounding_box_id -> max_long}, so cannot remove FD.

Trying Landing_site_name -> LS_description

F = {
Image_id -> url
Image_id -> bounding_box_id
Image_id -> metadata_data
Bounding_box_id -> min_lat
Bounding_box_id -> max_lat
Bounding_box_id -> min_long
Bounding_box_id -> max_long
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> FI_description
Featured_image_id -> date
Featured_image_id -> image_id
Featured_image_id -> title
}

LS_descriptioncannot be inferred from F - {Landing_site_name -> LS_description}, so cannot remove FD

Trying Landing_site_name -> mission

F = {
	Image_id -> url
	Image_id -> bounding_box_id
	Image_id -> metadata_data
	Bounding_box_id -> min_lat
	Bounding_box_id -> max_lat
	Bounding_box_id -> min_long
	Bounding_box_id -> max_long
	Landing_site_name -> LS_description
	Landing_site_name -> bounding_box_id
	Featured_image_id -> FI_description
	Featured_image_id -> date
	Featured_image_id -> image_id
	Featured_image_id -> title
}

mission cannot be inferred from F - {Landing_site_name -> mission}, so cannot remove FD

Trying landing_site_name -> bounding_box_id

F = {
	Image_id -> url
	Image_id -> bounding_box_id
	Image_id -> metadata_data
	Bounding_box_id -> min_lat
	Bounding_box_id -> max_lat
	Bounding_box_id -> min_long
	Bounding_box_id -> max_long
	Landing_site_name -> LS_description
	Landing_site_name -> mission
	Featured_image_id -> FI_description
	Featured_image_id -> date
	Featured_image_id -> image_id
	Featured_image_id -> title
}

Bounding_box_id cannot be inferred from F - {landing_site_name -> bounding_box_id}, so cannot remove FD.

Trying featured_image -> FI_description

F = {
	Image_id -> url
	Image_id -> bounding_box_id
	Image_id -> metadata_data

Bounding_box_id -> min_lat
Bounding_box_id -> max_lat
Bounding_box_id -> min_long
Bounding_box_id -> max_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> date
Featured_image_id -> image_id
Featured_image_id -> title
}

FI_description cannot be inferred from F - {featured_image_id -> FI_description}, so cannot remove FD.

Trying Featured_image_id -> date

F = {
Image_id -> url
Image_id -> bounding_box_id
Image_id -> metadata_data
Bounding_box_id -> min_lat
Bounding_box_id -> max_lat
Bounding_box_id -> min_long
Bounding_box_id -> max_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id
Featured_image_id -> FI_description
Featured_image_id -> image_id
Featured_image_id -> title
}

Date cannot be inferred from F - {featured_image_id -> date}, so cannot remove FD.

Trying featured_image_id -> image_id

F = {
Image_id -> url
Image_id -> bounding_box_id
Image_id -> metadata_data
Bounding_box_id -> min_lat
Bounding_box_id -> max_lat
Bounding_box_id -> min_long
Bounding_box_id -> max_long
Landing_site_name -> LS_description
Landing_site_name -> mission
Landing_site_name -> bounding_box_id

Featured_image_id -> FI_description
Featured_image_id -> date
Featured_image_id -> title
}

Image_id cannot be inferred from F - {featured_image_id -> image_id}, so cannot remove ID.

Merging FDs with same LHS

Merging,

F = {
Image_id -> url, bounding_box_id, metadata_id, metadata_data
Boundind_box_id -> min_lat, max_lat, min_long, max_long
Landing_site_name -> LS_description, mission, bounded_box_id
Featured_image_id -> FI_description, date, title, image_id
}

Forming Table for each FD

Tables are as follows

Images(image_id <pk>, bounding_box_id <fk>, metadata_id, metadata_data)
BoundingBox(bounding_box_id <pk>, min_lat, max_lat, min_long, max_long)
LandingSites(landing_site_name <pk>, LS_Description, mission, bounding_box_id <fk>)
FeaturedImages(featured_image_id <pk>, FI_description, date, title, image_id <fk>)

Removing subset tables

No subset tables, so no tables removed.

Global Key

The global key is image_id, featured_image_id which is contained in FeaturedImages. Therefore there is no need to add an additional table containing the global key.

Final Normalized Relations

Images(image_id <pk>, url, bounding_box_id <fk>, metadata_data)
BoundingBox(bounding_box_id <pk>, min_lat, max_lat, min_long, max_long)
LandingSites(landing_site_name <pk>, LS_Description, mission, bounding_box_id <fk>)
FeaturedImages(featured_image_id <pk>, FI_description, date, title, image_id <fk>)