Judgmental Eye

In this lengthy exercise, you'll tie together a number of important concepts:

- HTML
- CSS
- Forms
- Python processing of data files
- Flask servers
- Relational databases
- ORMs / SQLAlchemy

In addition, we'll introduce a machine learning algorithm in the final further study.

The overall goal of the exercise is to build a website where users can login and add or update ratings of films. If time allows, in the further study we will add another feature, which predicts how the users will rate films. This prediction is based on analysis of how other users rated that film, depending on how similar those other users are to the user. Lastly, we'll add **The Eye**, a system user with terrible taste in movies who will berate users for their movie ratings – again, using machine learning to decide how **The Eye** would rate things.

Object Relational Mappers

If you worked on the ***project-tracker*** exercise, you saw how we used classes to model objects that ultimately were stored in a database. In this project, we'll take this idea further, and introduce a tool called an ORM <https://en.wikipedia.org/wiki/Object-relational_mapping>.

In 2003, Martin Fowler <https://en.wikipedia.org/wiki/Martin_Fowler> documented a technique called "Active Record," a scheme which can be diagrammed like so:

Database Concept	Object-Oriented Concept
Table	Class
Column	Attribute
Row	Instance

In essence, a table definition is more or less equivalent to a class definition. Each column can be thought of as an attribute or property of that class. Each row is also analogous to an instantiation of the class. The analogy isn't perfect, but it serves us well enough. The analogy allows us to construct software that, through the magic of “introspection” (self-examination), can automatically write and execute SQL queries for us *without* the programmer having to stop and think about the SQL required to accomplish a task.

Here’s an example. Given the following SQL:

```
CREATE TABLE users
    (user_id SERIAL PRIMARY KEY NOT NULL,
     email VARCHAR(64),
     password VARCHAR(64));
```

Here is how you might set up the class:

```
class User(object):
    """A user of our website; stored in a database."""

    __tablename__ = "users"

    def __init__(self, user_id, email, password):
        """Create a user, given id, email, and password."""

        self.user_id = user_id
        self.email = email
        self.password = password

    @classmethod
    def get_by_id(cls, user_id):
        """Get a user from database by ID and return instance."""

        QUERY = """SELECT user_id, email, password
                   FROM users WHERE user_id = :id"""
        cursor = db.session.execute(QUERY, {'id': user_id})
        user_id, email, password = cursor.fetchone()
        return cls(user_id, email, password)

    def change_password(self, password):
        """Change password for the user."""

        QUERY = ("UPDATE users SET password = :password " +
                 "WHERE user_id = :id")
        db.session.execute(QUERY, {'password': password,
                                   'id': self.user_id})
        db.session.commit()
```

And, with that class, here’s how you would update a user’s password:

```
jessica = User.get_by_id(5)
jessica.change_password("my-new-password")
```

There's nothing wrong here yet, but if we wanted to be able to update the user's email address as well, we start having to write significant amounts of repetitive code.

An ORM provides us with a slightly different workflow. Instead of writing a bunch of code to handle SQL, it instead *peeks* at your class definitions ("introspects it") and uses the information gathered to **generate** appropriate SQL. Our ***User*** class definition changes:

Given this, our ORM can *deduce* the original schema we generated earlier. The generation of the SQL schema can be left to the software. Furthermore, our previous example of changing a user's password can be done as follows:

```
jessica = User.query.get(2)
jessica.password = "my-new-password"
db.session.commit()
```

The `change_password()` function no longer exists in that form; its existence is obviated as we can access columns directly as if they were object attributes, as long as we *commit* the database after every modification to an object. Overall, the amount of overhead code required to store data for an app dropped precipitously when ORMs first appeared, allowing lone programmers to single-handedly build a full-stack application in shorter time periods.

For this project, we will continue using SQLAlchemy <http://sqlalchemy.org> as our ORM.

There are other ORMs out there, each implementing the ideas in Fowler's book slightly differently.

> **Note: Other ORMs**
>
> The other primary competing Python-based ORM is the one that is bundled with Django <https://docs.djangoproject.com/en/dev/topics/db/queries/>. The one restriction for that one is that it cannot easily be used outside of Django, so we won't consider it here.

Setup

There are a number of Python libraries we'll need for this project.

We'll create a virtual environment and install them, using a ***requirements.txt*** file that has the names and exact versions of products we'd like to use:

```
$ virtualenv env
New python executable in env/bin/python
Installing setuptools, pip...done.
$ source env/bin/activate
(env) $ pip3 install -r requirements.txt
Downloading/unpacking Flask (from -r requirements.txt (line 1))
Downloading Flask-0.10.1.tar.gz (544kB): 544kB downloaded
...

Successfully installed Flask Flask-SQLAlchemy Jinja2 ...
Cleaning up...
(env) $
```

Awesome.

Investigating Our Data

The dataset we'll be using is something called the MovieLens 100k <http://grouplens.org/datasets/movielens/> dataset. It consists of many ratings of movies from users. We'll mine this data for correlations, but first we need to know what it looks like.

The data has already been unpacked for you in the ***seed_data/*** directory. Take a look:

- ***u.data***
- ***u.item***
- ***u.user***

These files have been extracted from the MovieLens 100k; in the original documentation that came with the data set was the following information:

u.item

Information about the items (movies); this is a `|`-separated list of:

```
movie id | movie title | release date | video release date |
IMDb URL | unknown | Action | Adventure | Animation |
Children's | Comedy | Crime | Documentary | Drama | Fantasy |
Film-Noir | Horror | Musical | Mystery | Romance | Sci-Fi |
Thriller | War | Western |
```

The last 19 fields are the genres, a 1 indicates the movie is of that genre, a 0 indicates it is not; movies can be in several genres at once (however, we won't be using genre information at all in this exercise).

The movie ids are the ones used in the ***u.data*** data set.

u.user

Demographic information about the users; this is a `|` - separated list of:

```
user id | age | gender | occupation | zip code
```

The user ids are the ones used in the ***u.data*** data set.

u.data

The full user data set, 100,000 ratings by 943 users on 1682 items. Each user has rated at least 20 movies. Users and items are numbered consecutively from 1. The data is randomly ordered. This is a tab (`\t`) separated list of:

```
user_id \t movie_id \t score \t timestamp.
```

The score column is an integer between 1 and 5 that will form the basis for our rating system throughout this exercise.

We don't use them for our data set, but it's good to understand the formatting for the time stamp here– they're integers, and measured in what UNIX calls "epoch time"–seconds since 1/1/1970 UTC.

What's the Model?

Spend a little bit trying to decipher the files before moving on. It will make it easier to remember that in this data set, "items" are movies.

Stop here and think about how these three files constitute a "model" – that is, how they cooperate together to provide a set of information. It might help to imagine how, given a movie name, you could find a list of the users who rated that movie.

Thinking About the Model

If you caught the copious hints, you should be thinking that each of these files is a table in a database. Every one of the columns in the file is the same as a database column. To reconstruct an entire record (*who* rated *what* movie) we first go to the ***u.data*** table to get a ***user_id*** and a ***movie_id***. We take those numbers and search their respective files for the row id that matches, then glue all three rows together.

Building the Database

Okay, so our data is in files and we need to put them into database tables. Great, we'll start writing a schema. Identify the tables we'll need to make, and sketch out the schema.

We're not going to use all the genre data for movies, nor are we going to keep track of users' genders or occupations.

However, we'll add authentication data to the user schema, adding both an email and password, while making the remaining user data optional. Sketch out a rough schema as well as any relationships between the tables (has many, belongs to, etc).

Going by our files, we can come up with the following skeleton:

Model

User

Name	Type
user_id	integer, primary key
email	optional string
password	optional string
age	optional integer
zipcode	optional string (technically, these aren't numeric)

Movie

Name	Type
movie_id	integer, primary key
title	string
released_at	datetime
imdb_url	string

Rating

Name	Type
rating_id	integer, primary key
movie_id	integer

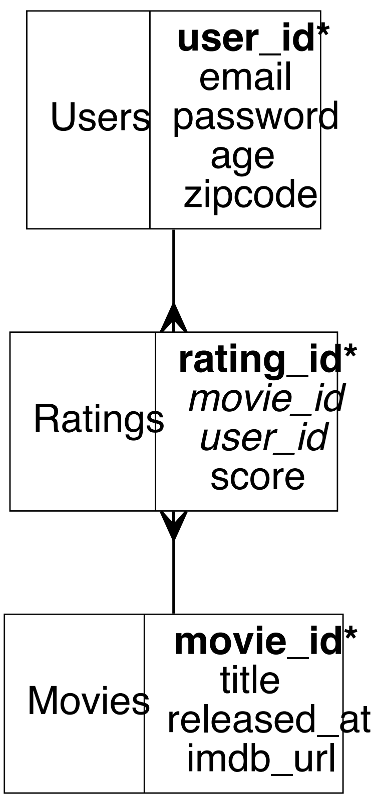
Name	Type
user_id	integer
score	integer

Relationships

- A user has many ratings
- A rating belongs to a user
- A movie has many ratings
- A rating belongs to a movie
- A user has many movies through ratings
- A movie has many users through ratings

We can draw that model as a diagram as such:

Model



Now, to write the SQL.

Well, not so fast. Writing SQL can be tedious work. It needs to be done, but it gets tricky remembering the syntax. We'll write *code* that writes our schemas for us.

First, look in your project directory. You should see a ***model.py*** file. We'll begin the alchemy.

SQLAlchemy is powerful software, and the process it uses to transmute python into SQL and back is indeed alchemical. While it would be most excellent for you to *understand* exactly what's happening, at this stage we just need to be able use it reliably. Trust the incantations, then open your ***model.py*** file, and we'll take a look at the ***User*** model sample that has been provided.

```
class User(db.Model):
    """User of ratings website."""
```

So far, the only thing out of the ordinary is the inheritance from a class named ***Model***, which we find on the ***db*** object. This is how we declare a class to be managed by SQLAlchemy.

This ***db.Model*** class is required for SQLAlchemy's magic to work.

The next few lines are how we define our table and its columns:

```

class User(db.Model):
    """User of ratings website."""

    __tablename__ = "users"

    user_id = db.Column(db.Integer,
                        autoincrement=True,
                        primary_key=True)
    email = db.Column(db.String(64), nullable=True)
```

We'll go over it line by line, but try not to find the deeper reasons for this syntax: this is a fairly non-standard use of python class attributes. It's allowed by the language definition, but ultimately, these lines we just added are SQLAlchemy specific and only make sense in that context. It's good to remember them, but it's equally good to remember how to look them up.

The first line:

```
__tablename__ = "users"
```

Simply informs SQLAlchemy that instances of this class will be stored in a table named ***users***.

The next:

```
user_id = db.Column(db.Integer, autoincrement=True, primary_key=True)
```

Tells SQLAlchemy to add a column to the table named ***user_id***. It will contain an integer, and be the primary key for our table: it will uniquely identify every row in the table.

The next line contains something slightly different:

```
email = db.Column(db.String(64), nullable=True)
```

This behaves as you'd expect, with the exception of the `nullable=True` part. That tells SQLAlchemy (and thus, PostgreSQL) that this column is optional. It's allowed to be ***NULL***. Since our MovieLens 100k data set is anonymized, we won't have any email addresses for any of the users we're given. However, to simplify things, we'll be using the same table to store *new* users who can log in via email, so we need to make the field available for them.

The remaining columns follow in a similar fashion.

The word ***String*** is not a built-in python class (that one is ***str***), nor is ***Integer*** (***int***, respectively). These are the SQLAlchemy-managed versions of the same data types. You'll find that they're imported from ***db***, at the top of the file. SQLAlchemy has a number of other data types as well, including datetimes, booleans, floats, etc., all imported from the same place.

The last thing of note is that there is no `__init__()` method. SQLAlchemy's ***Model*** superclass provides one for you that uses keyword arguments when initializing objects.

In our terminal window with the activated virtual environment, run your ***model.py*** with the `-i` option:

```
(env) $ python3 -i model.py
Connected to DB.
>>>
```

We've put some code at the bottom of the ***model.py*** file already that connects to the database. Open a second terminal window and type:

```
(env) $ psql ratings
```

to verify that the ***ratings*** database does not exist. You should see:

```
psql: FATAL:  database "ratings" does not exist
```

Now in your terminal create your empty database by typing:

```
(env) $ createdb ratings
```

Then, back in the same python console execute the method on the database connection that creates the tables:

```
>>> db.create_all()
```

Back in your second window type:

```
(env) $ psql ratings
```

This time you should see something like:

```
psql (9.4.4)
Type "help" for help.

ratings=#
```

Enter `\d` (the "d" stands for "describe") to see what tables are in the ratings database, and then `\d users` and you should see something like this:

```
ratings=# \d
                List of relations
 Schema |         Name          |   Type   |    Owner
--------+-----------------------+----------+--------------
 public | users                 | table    | hackbright
 public | users_user_id_seq     | sequence | hackbright
(2 rows)

ratings=# \d users
                                Table "public.users"
  Column  |         Type          |                        Modifiers
----------+-----------------------+--------------------------------------------------
 user_id  | integer               | not null default nextval ...
 email    | character varying(64) |
 password | character varying(64) |
 age      | integer               |
 zipcode  | character varying(15) |
Indexes:
```

```
    "users_pkey" PRIMARY KEY, btree (user_id)
```

Mind = **blown**

To Do

Quit both ***psql*** and ***python***.

Drop your ***ratings*** database (`dropdb ratings`).

Create two additional classes, ***Movie*** and ***Rating***, to hold the information that we want to keep from those files (refer to the SQLAlchemy tutorial <http://docs.sqlalchemy.org/en/latest/orm/tutorial.html> if necessary.)

Movie

Name	Type
movie_id	integer, primary key
title	string
released_at	datetime
imdb_url	string

Rating

Name	Type
rating_id	integer, primary key
movie_id	integer
user_id	integer
score	integer

> **Note: DateTime**
>
> Be sure to define your data type as ***db.DateTime*** for the ***released_at*** column in your Movie table – this will become important later.

When you're done, repeat the process of running `db.create_all()` to create your tables. Reopen your PostgreSQL database in your second window.

STOP. Get a code review. Seriously: a mistake here will be a pain to fix later, and we'd love to give you good advice on design.

Populating Our Tables with Data

In your PostgreSQL window, insert a new row into your users table:

```
ratings=# INSERT INTO users (email, password, age, zipcode)
ratings=# VALUES ("jessica@gmail.com", "mypass", 29, "94114");
```

Now, we will transmute SQL into Python. First, query to see your shiny new record in PostgreSQL:

```
ratings=# SELECT * FROM users;
user_id   | email                  | password |   age    |  zipcode
----------+----------------------+----------+----------+----------
1         |  jessica@gmail.com <mailto:jessica%40gmail.com>    |  mypass  |    29    |    94114
```

Switch to another terminal window and do the following:

```
$ python3 -i model.py
Connected to DB.
>>> jessica = User.query.get(1)
>>> print(jessica.email)
jessica@gmail.com <mailto:jessica%40gmail.com>
```

The `1` in the `get()` method is the id of the User we want to get from our table. If your database has a different id for the user you want to find, use that instead.

Before we go further, let's see what happens if we print out the user directly:

```
>>> print(jessica)
<__main__.User object at 0x10741f850>
```

When you print out an object in Python (either in a script or in the Python console), Python normally prints something like `<User object at 0x11244222>`, which just tells us the location in memory of that object. That's not very helpful; it would be more helpful to get some useful information for debugging what user we're dealing with.

Therefore, we'll add a magic method to ***User***, `__repr__()`. If you define this method on a class, when

Python tries to "represent" an instance of this class, it will use this instead.

```
    def __repr__(self):
        """Provide helpful representation when printed."""

        return f"<User user_id={self.user_id} email={self.email}>"
```

To get this new Python code, you'll need to quit the Python console and re-start:

```
$ python3 -i model.py
Connected to DB.
>>> jessica = User.query.get(1)
>>> print(jessica)
<User user_id=1 email=jessica@gmail.com <mailto:email=jessica%40gmail.com>>
```

That's helpful.

Let's update her password to be something more secure:

```
>>> jessica.password = "qfujf3"
```

Now, let's query the database to see if that worked:

```
ratings=# SELECT * FROM users;
user_id   |  email                   | password |   age    |  zipcode
----------+-----------------------+----------+----------+----------
1         |  jessica@gmail.com <mailto:jessica%40gmail.com>    | mypass    |  29     |  94114
```

The new password isn't there! What gives? Well, like when we did raw SQL (and not dissimilar to Git), we need to commit data after we've modified it.

In Python:

```
>>> db.session.commit()
```

And query again:

```
ratings=# SELECT * FROM users;
user_id   |  email                   | password |  age     |  zipcode
```

```
----------+----------------------+---------+---------+----------
1         |  jessica@gmail.com <mailto:jessica%40gmail.com>    |  qfujf3  |  29      |  94114
```

SQLAlchemy took our python and wrote the appropriate SQL update query for us behind the scenes. This is a powerful idea, because now we can write programs, only worrying about the classes and data we're interested in, and not how to write the SQL we need to save it somewhere.

Once more, for effect:

Reversing Direction

We inserted data in SQL, then got it back out on the python end, where we could update it. Now, let's do the reverse, where we insert data in from python. Let's make a record for Jada.

```
>>> jada = User(email="jada@gmail.com", password="abc123", age=25,
...             zipcode="94103")
```

If we query the database, we get nothing:

```
ratings=# SELECT * FROM users;
user_id   | email                | password | age      | zipcode
----------+----------------------+---------+---------+----------
1         | jessica@gmail.com <mailto:jessica%40gmail.com>     | qfujf3   | 29       | 94114
```

Right, we have to commit first. Actually, we have to do more than commit. Right now, we have a ***User*** object that we created in Python, but that isn't reflected in the database immediately. There are times when we want to do exactly this, so SQLAlchemy forces us to be *explicit* when we want to insert something into the database as well. We do this by *adding* an object to our session. Here, the Git parallel is particularly strong.

```
>>> db.session.add(jada)
>>> db.session.commit()
```

Now, in PostgreSQL, one more time:

```
ratings=# SELECT * FROM users;
user_id   | email                | password | age      | zipcode
----------+----------------------+---------+---------+----------
1         | jessica@gmail.com <mailto:jessica%40gmail.com>     | qfujf3   | 29       | 94114
2         | jada@gmail.com <mailto:jada%40gmail.com>        | abc123   | 25       | 94103
```

Now that our object has been "added" to the database, it is being tracked, and if we need to update it, we only need to commit after modifying it:

```
>>> jada.password = "bunnies"
>>> db.session.commit()
```

and to confirm:

```
ratings=# SELECT * FROM users WHERE user_id = 2;
user_id   | email                     | password | age      | zipcode
----------+---------------------------+----------+----------+----------
2         | jada@gmail.com <mailto:jada%40gmail.com>        | bunnies   | 25        | 94103
```

Let's do one more thing. So far, we've relied on PostgreSQL to assign unique ids to our users. We can specify an id when creating a user.

```
>>> juanita = User(user_id=5, email="juanita@gmail.com",
...     password="abc123", age=42, zipcode="94103")
>>> db.session.add(juanita)
>>> db.session.commit()
```

If we query the database, we should see this:

```
ratings=# SELECT * FROM users WHERE email="juanita@gmail.com";
user_id   | email                     | password | age      | zipcode
----------+---------------------------+----------+----------+----------
5         | juanita@gmail.com <mailto:juanita%40gmail.com>     | abc123    | 42        | 94103
```

Experiment with adding, committing, and querying to make sure you understand how data goes into PostgreSQL through Python, and how to get it back out. Add new records on both the PostgreSQL and Python sides, and use `.get()` to get them back out. Change some fields, then commit them back and see how the columns get updated. Do this for all three tables, then get ready to wipe them out.

First, drop your ***ratings*** database using the `dropdb` command. Then, recreate your database using the `createdb` command. Reconnect to your ***model.py*** file and run `db.create_all()` in order to recreate your ***ratings*** database.

```
(env) $ dropdb ratings
(env) $ createdb ratings
(env) $ python3 -i model.py
```

```
Connected to DB.
>>> db.create_all()
```

Reading Data From Seed Files

Now that we know how to insert single rows into the database, we have to *bulk insert* a bunch of our movie data. You'll find a file, ***seed.py***, which contains a rough outline of what needs to happen. You'll need to open up the seed files corresponding to each table, read each row in, parse it, then insert it into the database using our SQLAlchemy object interface.

The general steps are:

1. Open and read a file
2. Parse a line
3. Create an object
4. Add the object to the ***db.session***
5. Repeat until all objects are added
6. Commit

We've supplied the first, `load_users`, to give you a sense of what to do for the others. Read it carefully. Each of the files is formatted slightly differently, so you'll have to modify the second two functions to account for those changes.

There are two particular challenges to pay attention to as you write your own `load` functions:

- In the ***u.item*** file, the dates are given as strings like "31-Oct-2015". We need to store this in the database as an actual date object, not as a string that just looks like a date. To do this, you'll need to research the Python ***datetime*** library to find the function that can parse a string into a datetime object.
- The movies include the year of release at the end of the title, like "Balloonicorn's Big Adventure (2010)" – but we don't want to include that parenthetical date in the database (we're already storing the release date as a separate field, so it's duplicative, plus it's ugly). Find a way to remove it from the title.

Feeling stumped on your datetime conversion? Here's a hint:

Datetime Conversion

You will need to use ***strptime*** from the datetime library. Here's some example code:

```
if released_str:
    released_at = datetime.datetime.strptime(released_str, "%d-%b-%Y")
else:
    released_at = None
```

Autoincrement

Much like the Take-A-Number dispenser at the deli, Postgres uses sequences to set the values for autoincrement columns. By default, the sequence starts at 1. Since we loaded in the user_ids from the data file when we seeded our database, we haven't used the sequence yet. When we create a new user later on, Postgres will attempt to assign it id 1 (the first number in the sequence), and this will generate an error, because there already is a user with user_id 1.

To prevent this error, we've included a function ***set_val_user_id*** in ***seed.py***. This function queries users to find the maximum id, and then sets our sequence next value to be one more than that max.

If you want to better understand how this function works, enter psql from the terminal. Just as `\dt` shows a list of the tables, `\d` lists all tables, views, and sequences. After you seed the database, you can see that you have:

```
ratings=# d
                   List of relations
 Schema |          Name          |   Type   |   Owner
--------+-----------------------+----------+-----------
 public | movies                 | table    | user
 public | movies_movie_id_seq    | sequence | user
 public | ratings                | table    | user
 public | ratings_rating_id_seq  | sequence | user
 public | users                  | table    | user
 public | users_user_id_seq      | sequence | user
```

We are adjusting the users_user_id_seq, using the Postgres function ***setval***. You can read more about Postgres functions on sequences here <http://www.postgresql.org/docs/8.2/static/functions-sequence.html>.

Once you have written your importing code and satisfied yourself that it is importing all of the data properly, **ask for a code review**.

Once you've finished your code review, you can either, depending on your schedule:

- Further Study <further-study.html>
- Exercise: Judgmental Eye Part 2 <index-2.html>

- Solution <solution/index.html>