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# Moods and Triggers

Diagram

Description automatically generatedI used a modified version [1] of Russell’s Circumplex Model of Affect [2] as the mood model for my project. I considered several other models.

Figure 1 Russell's Circumplex Model of Affect (Modified)

The Valence-Arousal-Dominance model [2] (also proposed by Russell) was a front runner, but it’s third dimension (dominance) added an unnecessary complexity that I felt would not add enough value to the project to warrant handling the its extra complexity.

Another strong contender was the Ekman’s State Model - which attempts to enumerate the discrete emotional states categories, i.e. anger, disgust, fear, happiness, sadness, and surprise. This would fit well within the constraints of this project, but it seemed reductive from a user’s perspective.

Russell’s Circumplex Model of Affect was particularly attractive as it allowed 2 axes (valence and arousal) and 4 categories with which to classify each “mood” - see Figure 1. This would be useful during visualization of mood logs, as it attaches data potentially useful to the user to each emotion. I used a modified version of this model which classified 12 separate moods, 2 valences and 2 arousal levels.

For mood triggers I used activities the user engaged in – those that prompted the mood – and a free-text *notes* field. These activity triggers are sub divided into groups. Each user account, upon creation, is seeded with an Activity Group named *Default*, in which are nested two Activities – *Work* & *Exercise*. This will be demonstrated in the video report. User’s may add and remove activities themselves via the main menu to customize their experience.

To visualise the moods, I used the Chart.js library [3], which is included via a script tag’s src attribute in visual.ejs. I created a set of uniquely authorized routes on my API (in the visualRouter.ts). These routes are authorized not by API keys like the other API routes, but instead via the user’s login token JWT cookie set in the Authorization header of the request. This was done so that the visualization client-side JavaScript scripts can call each chart’s end-point as and when it requires the data (in an ajax-like fashion), instead of doing a potentially wasteful large query. I had to authorize these requests originating on the client-side without exposing API keys so I chose this method. All of the of the visualization route’s derive the user’s ID from the JWT token’s encrypted payload, ensuring a logged in user can only use these visualize endpoints to get their *own* data.

For the actual statistics rendered in the charts I decided on the following:

**(1)** Raw mood frequency bar chart. The frequency of each mood in that user’s log history is shown. A quick glance can show the user what their most common moods are!

**(2 + 3)** arousal and valence pie charts. These give an indication of how common each valence / arousal [2] in mood logs. This gives the user an immediately accounting of whether their moods are mostly positive or negative, and weather they are of low or high arousal.

**(4)** Summary line graph. This that displays the most common mod logged on each day that has at least a single log. This shows the most common daily mood over the entire time span the user has been logging their moods. Positive/ Negative valence moods are denoted with a green or red colouring respectively to make it obvious immediately which days were broadly positive, and which were negative.

**(5)** Activity/ mood relationships. That is a set of charts that relate the contextual activities the user recorded with the mood logged. When the main relationship tab is selected the user is shown a chart that shows the most common mood/activity relationships. This helps the user pinpoint what activities may be triggering specific moods regularly. This tab nests a number of sub-charts equal to the number of activities that user has on their account. Newly registered users will have only two charts (for default Work and Exercise activities), but my *testuser1* demo account has eight charts under this tab, as there is currently 8 activities associated with that account.

There is also an Introduction tab, that briefly explains the concept of Russells’ Circumplex model, links to the original paper, and gives a plain English description of what that means for the user.

# Requirements

* **Validation**
  + **Client**
    - **How**
    - **Why**
    - **How it looks**
  + **Server**
    - **How**
    - **Why**
    - **How it looks**
* **Config**

**User Registration:** When navigating through the website whilst not logged in, the user may click on a hamburger button [3] in the top right corner. This will display a modal that contains the login form, and a link to the registration page. The user clicks on the registration link and a registration form is displayed.

This form’s inputs are validated both client-side and server-side. When the user begins to enter data in any of the 4 inputs, keyup events are fired and caught by an attached event handler function named handleValidateInput - defined in ./app/public/script/validator.js – This method takes the input element and validation message div CSS selectors and a validation call-back function as parameters, and so is reusable for validation of all input fields. Additionally, the password and password-confirm inputs are also validated with a second attached event handler function named handleValidatePasswordInputsTogether (also from validator.js), which also validates the password and confirm password input fields contain the same value.

The server-side injects validation configuration data into the client-side by passing config data to the rendering engine via ExpressJS locals [4], which then stores required config data in client-side JavaScript variables in a script tag in the ./app/views/partials/top.ejs file’s EJS/ HTML <header> tags. The validation call-back functions are also embedded into the client-side in this <header> tag (from ./app/public/script/validator.js), for use throughout client-side scripts. This top.ejs file is one of the layout template partials and is loaded for every page, which makes the specified config data and validator functions available throughout the client-side.

Config data is defined by a configuration class named Config – defined in ./common/config/Config.ts - that reads data from JSON configuration files. This Config class is imported in various files throughout the app/ api (and partially passed to client-side as discussed above). This allows the client-side to access validation data for input fields such as minLength, maxLength, validation regex and a description containing a validation error message. Thus, to change all input validation throughout the app (or other config data such as the ExpressJS listening port), one must only change the data contained in the appropriate configuration file at ./common/config/\*.json. The validation regex is simple, it enforces a 8-20 character limit, and allowable characters of a-z A-Z and 0-9 on usernames; a 8-20 character limit, and allowable characters of a-z A-Z, 0-9, \_, -, ?, ! and \* on passwords; and emails simply have to be in the format example@website.topleveldomain (containing only a-z, A-Z and 0-9). In reality these regular expressions would need some further development.

The validation message div’s for each input are populated from this configuration data (description discussed above) when the page is loaded, and a custom hidden CSS class is used to hide it. The keyup event handler method handleValidateInput calls the validator call-back function on the input’s value property. The call-back function uses the regex specified in the injected configuration data to validate the field’s value. If deemed valid, it adds a valid CSS / removes the invalid CSS class, which styles it appropriately and applies the hidden class to that validation error message div; and the opposite if deemed invalid.

If a user bypasses the client-side validation (e.g. executing document.querySelector(‘#registration-form’).submit() in the console), then the server also validates all fields before the API is called. The validation regex is obtained by the server-side code from the same Config class discussed above.

If any form input data is deemed invalid, a 400 status is returned and registerfailed.ejs template is rendered, which has the login form component embedded, with an additional div displaying the error messages returned from the server. If all form input data is deemed valid, then a request is sent to the API’s api/user/register POST endpoint. This endpoint is handled by the ./api/route/userRouter.ts ExpressJS Router which calls the .api/controllers/userController.ts’s register() method. I did server-side validation again on the API side, which is perhaps redundant, but I found it difficult to decide between server-side validation on the web app or the API side, so I erred on the side of caution and put input validation in both.

This register() method then calls the register instance method on the mood Data Access Object (DAO – these are defined in .api/database/\*-dao.ts). This DAO handles all database operations for mood related activities. For registration the following operations are undertaken: (1) insert new user into tbl\_user and retrieves tbl\_user .user\_id attribute from new record, (2) inserts *Default* activity group into tbl\_activity\_group – and related to the user’s user\_id, and (3) inserts default activities in this group (*Work* and *Exersize*) – also related to the user’s user\_id. Each user has this data seeded so that they may latter add, remove and edit these contextual activities.

After database operations are complete a JSON response is returned to the web application (modelled by the ./common/response/RegistrationResponse.ts class). This JSON response indicates if the action was successful, any errors, if there are any as a string[]. If the API’s registration response indicates it is successful, the next route specific middleware function is called (controller.attemptLogin - discussed in next section), which logs the new user in.

If the registration was unsuccessful then the registerfailed.ejs template is rendered with the error strings returned from the API displayed above the form.

User input is checked at client, web app and API levels.:

* Client side the regular expression checks are used to enforce safe characters only. these regular expression checks enforce only safe characters are present.
* If these are bypassed input also sanitized server side via the same regex. As a precaution to the regex being changed into the future and introducing a vulnerability input is passed to the JavaScript native method encodeURIComponent(string) to escape all HTML characters. Its return is used to create the HTTP request’s x-www-form-encoded parameters destined for the API.
* The regex check is a

**DATABASE ENCRYPTION CRAIC HERE?**

**User Login:** The user logs in via clicking on the hamburger button [3] which displays the login form. This form also has client-side and server-side validation. This form employs the exact same method for client-side validation as the registration form (inject validation data from Config class on the server-side, store relevant config on client-side, validates using handleValidateInput event handler, which utilizes this validation config data, display error in an absolutely positioned div attached to input).

If the client-side validation deems the request valid, or client-side validation is bypassed by the user, then a call is made to the /api/user/login POST endpoint. Much like user registration, the web application’s userRouter receives the request and this time calls the controller.attemptLogin method. This method first validates the login form’s username and password inputs exist. If they do not a 400 with appropriate error messages, which are then passed to the loginfailed.ejs template where they are displayed to the user.

Then the apiCall() method from ./app/utils/apiCall.ts a method my web applications uses that abtracts the actual API call itself into

This protects against bypassing client-side protection of form validation.

If

# Authorization & Security

I specifically use the word Authorization in this section as it applies to allowing access to a service. The term authentication technically describes the application of various roles and that roles permissions to a user (e.g., user, super user, administrator) which are not present in my project. There are currently 3 main methods of authorization used in my project.

1. The user’s session is authorized on login restricted routes via the authorize (authorizes the user) and restrictedArea (requires user to be authorized to access any routes that use this middleware) middleware functions from ./app/middleware/. These are discussed in the video. The particulars of how a user receives their JWT cookie are discussed below and demonstrated in the video report.
2. Most requests from the web application to the API are authorized via API keys. The web application reads the current in-use key from environment variables. The dotenv [6] node module/ library is used to inject key/value pairs (including an active API key) from the ./.env file into environment variables. This .env file would not be committed to a repository as to not expose keys. The environment variables and their values, in reality, would be added to the server machine when the application is deployed to a production environment. The keys are stored in the tbl\_key table in the database and can easily be disabled by changing the active bit(1) attribute to 0 on a specific key. These keys are passed in the Authorization header of the HTTP request. The API checks the key both exists in the database, and has its active bit set to 1, otherwise it rejects the key and does not authorize the request.
3. Requests from the client-side scripts to the API’s visualRouter GET routes are authorized via the user’s login cookie named token. It is placed into the Authorization header of the request. The API reads this token, verifies & decrypts it, and the user’s ID is read from the JWT’s payload. In this manner the client-side scripts can only successfully GET resources for an account they have the login details for.

## Login

Table 1 Example HTTP requests using each auth method

The web application manages authorization using JSON Web Tokens (JWTs). The user navigates to the login form, enters their username and password, and submits. The form then sends a HTTP POST request to the /login route of the web app. Internally this route‘s middleware packages up the submitted username and password into a new POST request to be sent to the API’s /api/user/login route.

|  |
| --- |
| **(browser to web app) – open routes / no auth**  POST /user/login HTTP/1.1  Host: https://localhost:8443  Content-Type: application/x-www-form-urlencoded  username=exampleusername&password=examplepassword  **(browser to web app) – JWT cookie authorized routes**  DELETE /user/deleteuser HTTP/1.1  Host: https://localhost:8443  Content-Type: application/x-www-form-urlencoded  Cookie: token=<login JWT>  **(web app to API) – API key authorized routes**  PUT /api/mood/<userId>/<entryId> HTTP/1.1  Host: https://localhost:8443  Authorization: <API key from environment variables>  Content-Type: application/x-www-form-urlencoded  activities=activitiesData&notes=notesData  **(browser to API’s visualizeRouter) – JWT cookie authorized routes**  GET /api/visual/moodFrequency HTTP/1.1  Host: https://localhost:8443  Authorization: <login JWT> |

The API receives this request and attempts to authorize the request via the middleware authenticateRequestBySource. This middleware checks the database for the keys existence and to ensure it is active, otherwise it rejects the request.

This middleware reads the Authorization header from the request, then queries the database tbl\_key table to check if the key valid – i.e. that is it both exists and has its active bit(1) attribute set to 1.

If the key is valid (present and active), the request is authorized by the middleware and next() is called to move onto the next route specific middleware.

If the key is not valid, then the API returns a status code 401 (Bad Request) and an accompanying JSON response body (modelled by my SuccessResponse class) indicating the request is not authorized and was rejected. This logic will be discussed below.

Once authorized, the route specific middleware is then called (in this case userController.login(req, res, next)). This middleware then processes the request as follows:

The POST body is validated to contain the required properties (username and password) as demonstrated in the video. If it does not, a 401 response is returned with a JSON body modelled by my LoginResponse class, which indicates the login attempt’s success with a boolean, and optionally token and error properties. The latter being an array containing various validation error messages (eg. “no username provided”).

If the post body is valid, then the controller calls the AuthApiDataAccessObject.login(username, password) method, passing in the provided username and password as parameters. This data access object exists to maintain separation of concerns. All authentication database queries/ statements are housed in the API’s two data access objects.

This auth DAO first confirms the user exists by querying the database for user data for users with the username equal to the POST body username property.

If the user does not exist, a 401 is returned with an appropriate error message (i.e., “This username does not exist”). If the user does exist then the password submitted during log in is hashed with the same salt as the stored password from the database, and the submitted and stored passwords are then compared for equality (see ./api/utils/crypt.ts).

If the username and password combination is accepted, the API constructs a JWT with a payload containing the user’s username, email, and id (id primary key from DB), and an expiry date/time stamp in the form of a Unix time stamp.

The API returns a status of 200 with the LoginResponse modelled JSON body to the web app that contains the JWT. The web app receives this response, and if the success property is true, and the response contains a token property, the token is retrieved and stored in a cookie on the user’s machine named token.

If the success property is false, the loginfailed.ejs template is rendered with a 401 status code. If the success property is true and the token property is undefined, or otherwise falsy, the user is redirected to the /error route in the fallbackRouter (with a status also set to 500). This indicates to the user that an error has occurred on the server.

## Authenticated Users & Restricted Areas

When a user attempts to access any part of the web site, a middleware function named authorize then attempts to the read the JWT from the token cookie and verify it. It does so by attempting to decode the token into a JavaScript object using a secret key stored in environment variables/ .env file as discussed above. As cryptography is an area of utmost importance, and the technical level required to implement it safely is relatively high, I decided to install and import the jsonwebtoken node module. This gives us access to the verify() and sign() methods, which can be used to verify/decode and create JWTs respectively. I’ve wrapped the use of these two functions in my own custom jwtHelpers.ts module, so that changing the library used to sign and verify tokens can be done relatively easily – by editing this single module.

~~In my project this secret is in the form of a single unchanging value that is accessible in this jwtHelpers.ts module via the verifyToken() (figure x) and createToken() methods. This module is imported by both the web app (in the middleware authenticate) and the API (in the middleware authenticateRequestByJwt and in the class AuthApiDataAccessObject), allowing both to process these JWTs in the same manner. In reality both the API and web app would be deployed with the secret in a configuration file, and not be so tightly coupled to a utility method directly like this.~~

The authorize middleware sets an ExpressJS locals [5] variable named authed to true or false, denoting if the user was successfully authorized or not (i.e. cookie named token with a valid JWT signed with the apps encryption key is verified or not). All login-restricted routes then subsequently use the restrictedArea middleware. This simply checks to see if this ExpressJS locals authed variable is true, and if it is not, rejects the request and ends the request response cycle with a 403 Forbidden response and renders the forbidden.ejs template.

~~inside the ExpressJS Response object is declared, if the token was successfully verified, it is initialised to true, and otherwise to false. This expressJS local boolean serves as the flag by which the site may decide to permit access to a given route (note all variables assigned as properties of the res.locals object are then accessible in the template files. res.locals.example set in a middleware function is then accessible as example in a template rendered by that route). All authentication-restricted routes call another middleware function named restrictedArea, that checks this flag, and if it is falsy (e.g., null, undefined or false - among others), then the user is redirected to a /forbidden route, that simply informs the user this route is forbidden without a successful login.~~

~~Using this methodology, my web application’s login-restricted routes can allow access to authenticated users only.~~

## API Authentication

The API has a primary method of authorization for requests originating from the web application’s server/ back-end and another secondary method for HTTP requests that are originate from client-side script charts.js.

The primary method of authorization is via that of an API key set in the Authorization header.

This API key is ensures only allowed applications/ services can consume my API, and protects the data within from unauthorized access or editing.

When authorizing a user via JWT, If the current time exceeds the expiry time of the JWT payload then the token is cleared from the user’s computer, logging them out automatically. This could do with further development. Perhaps updating the expiry time every time the user authorizes a request using the token, meaning it automatically logs out after a set time of inactivity, rather than a set time from login.

# REST API Implementation

The RESTful API I developed for this project was in the form of an NodeJS/ExpressJS application wrapping a MySQL database running on an Apache Server, managed via XAMPP. For the purposes of a university project the API is mounted via the main web application’s app.ts as an ExpressJS Router, although it could easily be deployed as a separate Express application.

Graphical user interface, text, application, website

Description automatically generatedThis Router is defined in./api/api.ts. Its routes are divided into 3 groups, /user, /mood and /visual, which are themselves ExpressJS Routers, each with its own area of concern. Authorization was discussed in its own section above, but the former two are authorized via API keys and the latter via a JWT.

Figure 6 API keys stored in tbl\_key

~~The keys are passed via the Authorization header of requests they receive. They are randomly created unique (enforced via uniqueness constraint in the table) GUIDs [5] stored in the tbl\_key table of the database (Figure 6). They can be easily disabled by changing the active bit(1) attribute to 0. The API’s ExpressJS middleware function that authorizes the API key checks for this flag when validating the key. The API key in use by the web application is stored in an environment variable (more specifically it is injected into the environment variables from a .env file using the dotenv node module).~~

## Endpoints

A list of all API endpoints follows, with any parameters replaced with their type as so <<number>>. All endpoints accept application/x-www-form-encoded content type in request bodies. All endpoints use the building express Response method .json() [6] to convert from TypeScript response objects to JSON via JSON.stringify(). These response objects, discussed below, are stored in the ./common/response/ folder. Most of them extend SuccessResponse, barring some specific use case response objects such as EntryDataResponse.ts.

./api/routes/userRouter.ts

**POST /api/user/login**

Expects a POST body containing username & password key/ value pairs, and returns a response modelled by LoginResponse.ts. If post body is missing data, or if the passed username / password fail their regex tests from Config as discussed above, returns a 400 with appropriate message(s). If username and password are correct a 200 is returned with a login JWT. If the username and password combination is incorrect a 401 is returned.

**POST /api/user/register**

Valid POST body to contain username, email and password key/ value pairs, and returns a response modelled by RegistrationResponse.ts. If post body invalid, or if the data from the POST body fail their Config regex tests, returns a 400 with appropriate message(s). The database is queried to check if the username or email has already been used, and if so returns a 409 Conflict with appropriate message(s). If all inputs pass validation and the user was created successfully, a 200 is returned.

**DELETE /api/user/<userId>**

Requires no body. The user ID is read directly from route parameters and calls a stored procedure named usp\_delete\_account(userId)that deletes in specific order (due to foreign key constraints), log entry activities, log entry images, log entries, context activities, activity groups and finally the user data. Returns a 200 if deleted successfully, a 400 if the userID request parameter is non-numeric and 404 if that user is not in the database.

**GET /api/user/<userId>**

This route is used for populating the form data in the Account Details page accessible via the hamburger menu. If the userID parameter is a valid user ID, a 200 is returned with a JSON body modelled by AccountDetailsGetResponse.ts. If the userID parameter is non-numeric a 404 is returned and if the userID does not exist in the database a 400 is returned. These latter two have response modelled by the SuccessResponse.ts class.

**PATCH /api/user/<userId>**

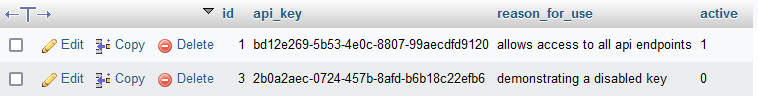
This endpoint is used to partially update a user resource (hence PATCH not PUT [9]), that is, it updates the username and email, but does NOT update the user’s password. Returns a 200 if the user ID is numeric, and is a valid users ID and returns a 404 if the user ID is not found in the database. Both responses return a JSON body modelled by AccountDetailsGetResponse.ts. Returns a 400 if username or email are absent from the request body, or if userID is a non-numeric value, with a response body modelled by SuccessResponse.

PATCH /api/user/<<userId>>/password

|  |  |  |
| --- | --- | --- |
| **Route** | **Method** | **Description** |
| **Router: ./api/routes/userRouter.ts** | | |
| /api/user/<<userId>> | POST |  |
| /api/user/<<userId>>  /api/user/<<userId>>/password | GET | Requires a number be passed via route which express exposes as a query parameter, and returns a response modelled by AccountDetailsGetResponse.ts. Simply returns the user details for the account.ejs template which allows the user to change email and password. |
| /api/user/<<userId>>  /api/user/<<userId>>/password  Router: ./api/routes/moodRouter.ts | PATCH | Again requires a userId parameter, updates the email and username data for a user. It is a PATCH not a PUT as it does not update the entire *user* resource in the database. |
| DELETE |  |
| PATCH |  |
| /api/mood/<<userId>>/new |  |  |
| /api/mood/<<userId>>/new  /api/mood/<<userId>>/list | | | GET | Get the form data required to display the mood logging form/ template. |
| /api/mood/<<userId>>/new  /api/mood/<<userId>>/list  /api/mood/<<user ID>>/<<entry ID>> | POST | Create a new mood log/ entry. |
| GET | Get all the mood logs for a particular user, processed and sorted into days, chronologically in descending order. |
| /api/mood/<<user ID>>/<<entry ID>> | GET | Gets the a specific mood log’s data, required to display the edit log page. |
|  |  |  |
|  |  |  |
|  | PUT | Update a mood log entries contextual information (notes and activities). I went with PUT instead of PATCH as I am updating all allowable attributes of the resource at once. |
| DELETE | Delete a mood log entry |
|  |  |

# REST API

All database operations performed by the web application are done so through a RESTful API which is also an ExpressJS application. It is divided into 3 ExpressJS Routers - *authRouter, moodRouter* and *visualizeRouter*, to maintain separation of concerns. As discussed in the [Security](#_Authentication_&_Security) section, requests to the *authRouter* and *moodRouter* are authorized via API keys and the *visualizeRouter* is authorized via JWT– both sent as Authorization headers.

 Currently my database has a table named *tbl\_key* (Figure 6), in which are stored API keys that the API will accept. New API keys can be added simply by inserting into this table. Old/ current keys can be deactivated by simply updating the active bit(1) attribute to be 0. The code in the API that checks the Authorization header for this API key can be seen in Figure 6. The API retrieves the Authorization header prior to this line, and forms a prepared SQL statement which checks both the key exists, and is currently active. The *format()* function is provided by the mysql2 node module/ library, and allows us to prepare SQL statement with escaped strings, to prevent SQL injection attacks. In this manner a key may be deactivated once compromised, or of a certain age.

|  |
| --- |
| const sql = format("SELECT COUNT(\*) AS `count` FROM tbl\_key k WHERE k.api\_key=? AND k.active=1", [authHeader]);  // evaluates to  // SELECT COUNT(\*) AS `count` FROM tbl\_key k WHERE k.api\_key='bd12e269-5b53-4e0c-8807-99aecdfd9120' AND k.active=1 |

Table

Description automatically generated

Figure 7 Current API Keys

Figure 8 API authentication code

Figure 9 API Check code

The database is then queried and if the key does not exist, or is not active (*count* returned is 0) then the API key is rejected, and a 401 Not Authorized status is returned with a request body modelled by my *SuccessResponse* class.

Figure 10 API Keys storage in DB

|  |
| --- |
| {      "success": false,      "errors": [          "You are not authorized."      ]  }  Figure 11 Not Authorized SuccessResponse |

If the key does exist, and is active (*count* returned is not 0), then the *next()* Express routing callback function is invoked, which moves the now authenticated request onto the next relevant route.

# References

|  |  |
| --- | --- |
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