STREAMLINING THE DESIGN AND MATERIAL SELECTION PROCESS

Automating material selection process through relational databases and apis.

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Abstract. The process of material and furniture selection can be streamlined and automated when two servers are given the opportunity to communicate with each other. This is realised through the use of relational databases and web servers, Django, and restful APIs. Through an agile design process, a digital prototype of the material database is able to be created, tested, evaluated and launched. The database encompasses a Django framework with an admin page to manage objects. Views are then written for the material database and the content is serialised to return either text or JSON files and published onto a domain for client server access. Simultaneously, a CSS storing data for different styles of rooms is being developed to access objects from the material database. These two systems are able to community with each other by sending and receiving data.

Ultimately a material database utilising restful architecture, relational databases and Django is created to streamline the process of material selection. This allows for any computer to access data from the material database.

Keywords. Material Database, Rest APIs, Django, Relational Database, Restful Architecture

1. Introduction

This research paper examines the process behind creating a material database using relational databases and restful APIs. This topic is investigated to streamline and hopefully automate the process of design in architecture. The paper strives to automate processes in architecture through integrating methods utilised in computer science. The end result of this research will optimistically result in a digital prototype which can streamline the process between designing and material selection.

1. PROBLEM STATEMENT

Design and material selection in architecture has always been static and traditional in their method of procedure. These two processes are not only time consuming, but they disallow the ability for firms to manage more projects and sometimes causes issues in the material selection process. This problem is not limited to designers. Manufacturers and material suppliers are physically delivering the material samples which is inefficient, laborious, and unsustainable. If the material selection process can be streamlined and automated in this research paper, the end result will save firms and suppliers valuable time.

2. MOTIVATION

Architectural practices do not make use of technology and science that is readily available to the industry. As “tools for engaging with design and architecture are becoming more… accessible”(Poustinchi, Ebrahim, 2018), there is a need to “question conventional methods of design”(Poustinchi, Ebrahim, 2018). If the project contains man details such as many different rooms with many different size requirements, or if the interior of a room is repeated numerous times with small or minute changes in each room, then the project becomes arduous and time-consuming. Architects exert a magnitude of time resolving these issues, when they should really be utilising their time on design issues that are more pressing and complex. However, with the design and material selection process automated, materials can be selected in the span it takes to modify one room or research one material. Architects must learn to “handle the inclusion of ubiquitous computing systems into the built environment” to counter against this inefficient use of time and resources. Furthermore, by switching to an online material database designers will no longer need hunt through physical material libraries to select a material as the online material database will be able to store an increasingly large amount of finishes and furniture. With the possibility that design and the material selection process can be streamlined, boundaries will be exerted in this paper to further investigate and experiment with this issue.

3. RESEARCH OBSERVATIONS

Materials selection is a very important aspect within an architect's process of design. Some would argue that materiality in architecture combines the "functional with the symbolic and decorative" (Ashby and Johnson, 2014). Hence, the reason for the necessity and high regard for a materials library within a design firm. Currently, the process for selecting materials is a time consuming task for designers. The content creation of material palettes and manually material section process by designers greatly reduces the firm's ability to tender more projects. Whilst the concept of creating an online material database is far from recent, the use of restful apis and relational databases in addition to the added bonus of storing different file formats(png, CAD, 3DsMax) on the database differentiates it from other existing databases. One of the advantages of using a relational database is that the database will be able to "manage huge amount of data in a consistent and stable manner" (Navneet Kumar, B.K, H.L and Ashkor, 2016) which can also be recovered and accessed from anywhere and anytime. Storing data digitally means that the data can be updated, processed and shared between computers (Nigrelli et al., 2013).

4. RESEARCH AIMS AND OBJECTIVES

The overall aim of this research project is to develop a streamlined process of material selection through an online database. This digital material database will not only be time saving, it will also provide a place for the design firm to collectively store and build a safe and easily accessible storage system. In this way, firms can minimise miscommunication and frequent negotiations between clients and designers. The use of restful architecture, apis and relational databases will greatly improve its processing and storage prowess as well as allow the system to be completely accessible anywhere and everywhere. Additionally, the development of the material database will also be able to reduce time, energy and resources spent on material selection. This is impactful towards design firms and material suppliers who invest time into procuring physical samples and creating mock ups. Designers will also have the ability to compare and contrast different material samples together without requesting for a physical sample to be delivered. As mentioned by Ramalhete, "designers can stay updated" through material databases which "enable designers to access information online about a great scope of materials and processes" (Ramalhete, Senos and Aguiar, 2010). The use of computers will allow designers to effectively congregate all materials in one place, and allow for accessibility and convenience to those objects.

This research project will aim to be one of a three part series in which all three parts will contribute to the standardisation of interior design for hotels. These three parts are researched separately but closely aligned to each other because of their relevance to each other. The first part is determine the floor level, room layout and space requirements for the room. The second part is taking data from the first section and determine the level of luxury and materials required for the room. This system then requests for materials and finishes from the material database to complete the interior design of the room. The material database can exist on its own and be accessed by the client's own API, however, by using the other two programs, the process of designing a hotel room can be standardised and streamlined. The computer is a necessary took for this task as there is "A growing demand for computer tools that can efficiently store, update, process and share the collected data" (Nigrelli et al., 2013).

2. Background Research

1. ENHANCING DESIGN DECISIONS IN MATERIAL SELECTION

Material selection is an arduous task for designers and even more so for novice designers who aren't equipped with adequate knowledge of material properties for existing materials.

Information of a material should be readily available to designers to assist them in selecting an appropriate material suitable for their designs. In order to overcome this challenge, a company has suggested linking a reference library of material application failures to an automated knowledge based material selection system which can alert the designer when a material with a record of failing is selected.

Design failure can be prevented in the same method by implementing the history of material application failure in the material database. In the Cambridge Engineering Selector Software, designers are able to “compare materials, mechanical properties, process abilities and eco properties when selecting materials”(Ramalhete, Senos and Aguiar, 2010). As noted by Ashby, designers should consider materiality at “every stage of the design process”(Ramalhete, Senos and Aguiar, 2010). They must consider their cost, processing methods, limitations, function of the component, product appearance, complexity of the produced form, environmental aspects, colour and odour.

However, this is not entirely possible as material selection would require “an established design concept with known dimension and specification with assembly drawings” (Ramalhete, Senos and Aguiar, 2010). This paper hopes to answer this challenge by creating a feedback loop between the three parts.

2. DIGITAL TOOLS FOR MATERIAL SELECTION

The increasing amount of standardised materials and demand from users and designers has led the industry to create a diversity of databases and softwares for material selection. Although some designers are choosing to adhere to traditional materials databases, most are opting for online material databases that are able to grant access to information to a large variety of materials and process.

The history of online material databases is complicated and detailed. The first record of a web portal, “Design Insite” dates back to 1996 and was created as a manufacturing guide for designers. In 1997, the internet database Material Connexion was launched with library samples from New York and Milan. This database was executed by steps using images but had imprecise data. During 2001, Europe’s first private library of materials, “Materio” was announced. Materials were chosen based on “visual, sensorial features, potentialities and probabilities of innovating” (Ramalhete, Senos and Aguiar, 2010). Later, a checklist through a questionnaire method was proposed by Edwards in 2005. Other designers such as Dezino created reports, CDs and databases that were able to showcase recent trends and materials. In 2007, Material Works improved the usability of the interface to create a better interaction between human and machine. Later web portals arose to further broaden the scope of material selection by connecting to a variety of material suppliers. In modern day, Mat Web is one of the most successful and rigours material database which consists of over thousands of materials and their properties, including technical, physical, mechanical, thermal, optical and electrical.

This project’s material database aims to further improve existing designs within the industry and be inclusive of all material properties deemed relevant and important to designers.

3. RELATIONAL DATABASES

A relational database is not a recent concept. However, it is still used commonly for storage purposes because it is able to store heterogenous information that can be retrieved through a series of web search queries. It is an efficient method of storing and managing huge amount of data in a stable and dependable way. In comparison to traditional storage conventions, databases are more useful as lost data can be recovered and any data can be accessed. Relational databases runs on a table format and has datasets and subsets which holds information about “depositional elements including original numbering, naming convention and element type” (Navneet Kumar, B.K, H.L and Ashor, 2016). These data is arranged by tables with data arranged in rows and columns.

One of the many benefits of using an online database is that it allows for comparison of data between two systems. They are also able to filter and transform data. Relational databases are robust, reliable and flexible. However, one of the many limitations of a relational database however is that it cannot process, update, modify, or join relationships of larger database tables efficiently. It fails when generating massive amounts of data and unstructured data. The database also has to be complete, otherwise the entire transaction fails. However, if any problem occurs, all transactions will be regenerated into their original state.

4. APIS AND RESTFUL ARCHITECTURE

Restful apis is an application interface which utilises HTTP requests to get, put, post and delete data. REST architecture is a representational state transfer technology which can usually be found in web development services. Requests are made from a client side from a website or an application to an API. This request allows the user to search for resources using URi quest strings which returns a list of items fulfilling the criteria given (Li, Chou, Zhou and Luo, 2016). This will be useful for the paper's material database development as it can generate those operations on any data form.

3. Research Methodology

In order to create a holistic material database, research was conducted to inquire into the different types of material databases available within the current market as well as the details and framework of these databases. This is then superseded by researching the material properties that are essential for an architect to design. Finally, the advantages and disadvantages of using either a relational database or a object oriented database was considered to confirm the right database style was chosen correctly.

1. OVERALL DESIGN OF MATERIAL DATABASE

An agile process was proposed to outline the work flow for the material database. Research into different types of existing databases were conducted, and very specific databases involving topics of other industry related issues such as health or automobile were not included in the investigation.

There are two alternative paths to creating a material "database". The data can be stored in a traditional online database, or it can be stored using a software system. General databases is "a tool with information regarding one or several material families and their properties" (Ramalhete, Senos and Aguiar, 2010), and a software is "an application that manages the information of one or several databases". According to Ramalhete, a material database has to contain visual information and represent more than one material family (Ramalhete, Senos and Aguiar, 2010). There are also two types of material selection software, one is an information software which stores technical information on materials and consists of a slower search system which makes little use of user interface interaction. The other is an inspiration software which allow users to access visual information about a large variety of materials. Most software system searches are conducted manually through name, properties, classes and keywords. Although the existing models were created to reduce costs, improve efficiency and facilitate innovation, the user finds it challenging to complete the questionnaire for material registration on the website. Additionally, an abundance of unrefined databases also means materials can't be contrasted against each other.

Ultimately, it was agreed that the interface quality, the amount and consistency of data and accessibility are the three most important aspects when creating an online material database. The interface quality will be ranked from poor, average to strong for human readability and machine readability. The consistency and amount of data will be rated poor, average, excellent.

The material database created will be rated against existing database to confirm all existing issues are resolved, as well as the implementation of new and innovative design strategies into the new database.

2. THE MAINFRAME AND EXECUTIVE OF MATERIAL DATABASE

The online web server consists of many different components. The python based framework will be written using Django and data can be accessed using a restful API. Python and Django were chosen for this project because of its simplicity, adaptability, consistency and scalability. After the completion of the code, the web server will then be hosted onto a domain which allows for real time accessibility from any computer or client server. The speed and accuracy of the returned results for the search engine will be evaluated to assess the credibility and functionality of the database. These two areas will be ranked in terms of slow, average and fast for speed and poor, average and excellent for accuracy.

4. Experiments

1. ADAPTING A NEW MAINFRAME ONTO AN EXISTING MAINFRAME

A first attempt to built a wireframe for the project was undertaken to test out different available functions and url paths for clients and servers to access. This initial test would produce the main framework which incorporates all essential elements for the development of the database.

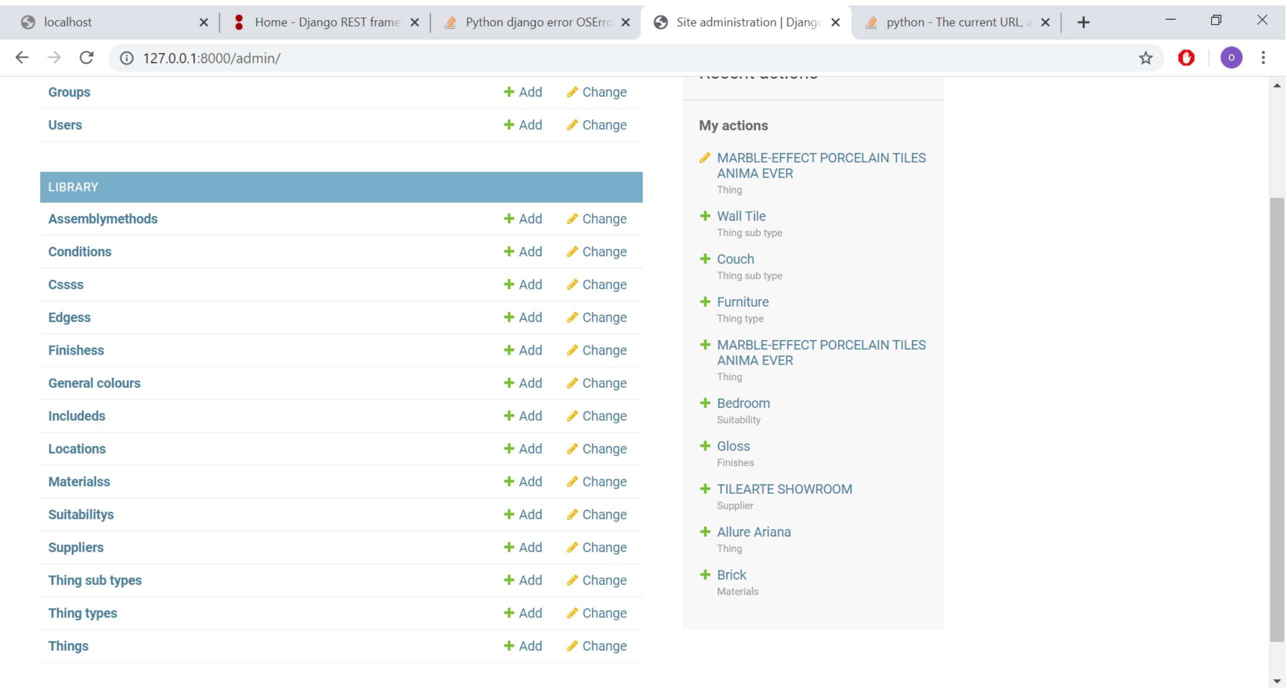
The basic framework is a polls application which allow users to vote on an answer to a question and view their votes in another page. There are two components to this, a public site which allows for unrestricted access, and an admin page that lets the creator add, modify and remove questions and answers. Once Django is installed and the project file is downloaded, a project file appears on the local computer system appears with several core development files. These files are essential as they help the user interact with the project in numerous ways, including adding and removing url paths. Once completed, the Django development server is initiated to access the web server locally.

When the fundamental aspects are completed, the model classes or database tables can now be created. The initial test requires the user to create a question and a choice, however, the application needs to be modified to a material database, hence, a model of “things” was created with classes. These models included objects such as material and finishes, and the classes consists of table values such as colour, slip rating, finish and sustainability rating. These classes are then registered into the url.py file which can then be accessed and modified using the local server.

The application is added into the INSTALLED_APPS setting.py to include the app in the project. These changes that were made is then altered through the make migrations command which allows for the changes to be updated in the models.

To create an human readable interface for user, an admin page was created to add, change and delete content. To link the material database with an admin interface, the admin page is registered in the admin.py file. In this instance, the material database is able to be modified in the admin page thats run by local host in FIGURE 1.

FIGURE 1. Image of admin interface on local server.



This method was successful as the base framework was correctly built and could lend itself to reusability again. The admin interface was also easy to use and understand as a novice learner would be able to navigate the different functions of the interface. Furthermore, the Django framework and its filing system allowed the user to navigate between different files and examine the functional properties it has on the overall application. It cannot be disregarded that Django is an efficient and effective web development system that lends itself to novice web designers.

TABLE 1. Table of Interface Evaluation Results.

Criteria	Admin Interface Quality	Client Interface Quality	Machine Readability
Rating	Strong	Poor	Strong

2. THE ADVANTAGES AND DISADVANTAGES OF RELATIONAL DATABASES AND SELECTION OF ESSENTIAL MATERIAL PROPERTIES

There are numerous advantages to utilising a relational database, however, there are also many disadvantages to using one for building a material database. It is proven that relational databases are a self recording database. The information and data stored within is easy to access, retrieve, update and maintain. There are also additional supports for retrieving data, reporting and summarising. The data is stored in a stable and reliable manner. Data collected from the database is predictable and usable. However, relational databases cannot support high scalability. Data needs to be complete and whole when entered, otherwise the database will fail to run. Furthermore, the more complex the data is, the more complicated the relations between each data becomes. This might generate an isolated database where information is not able to be distributed. This impacts on the efficiency of the database storage.

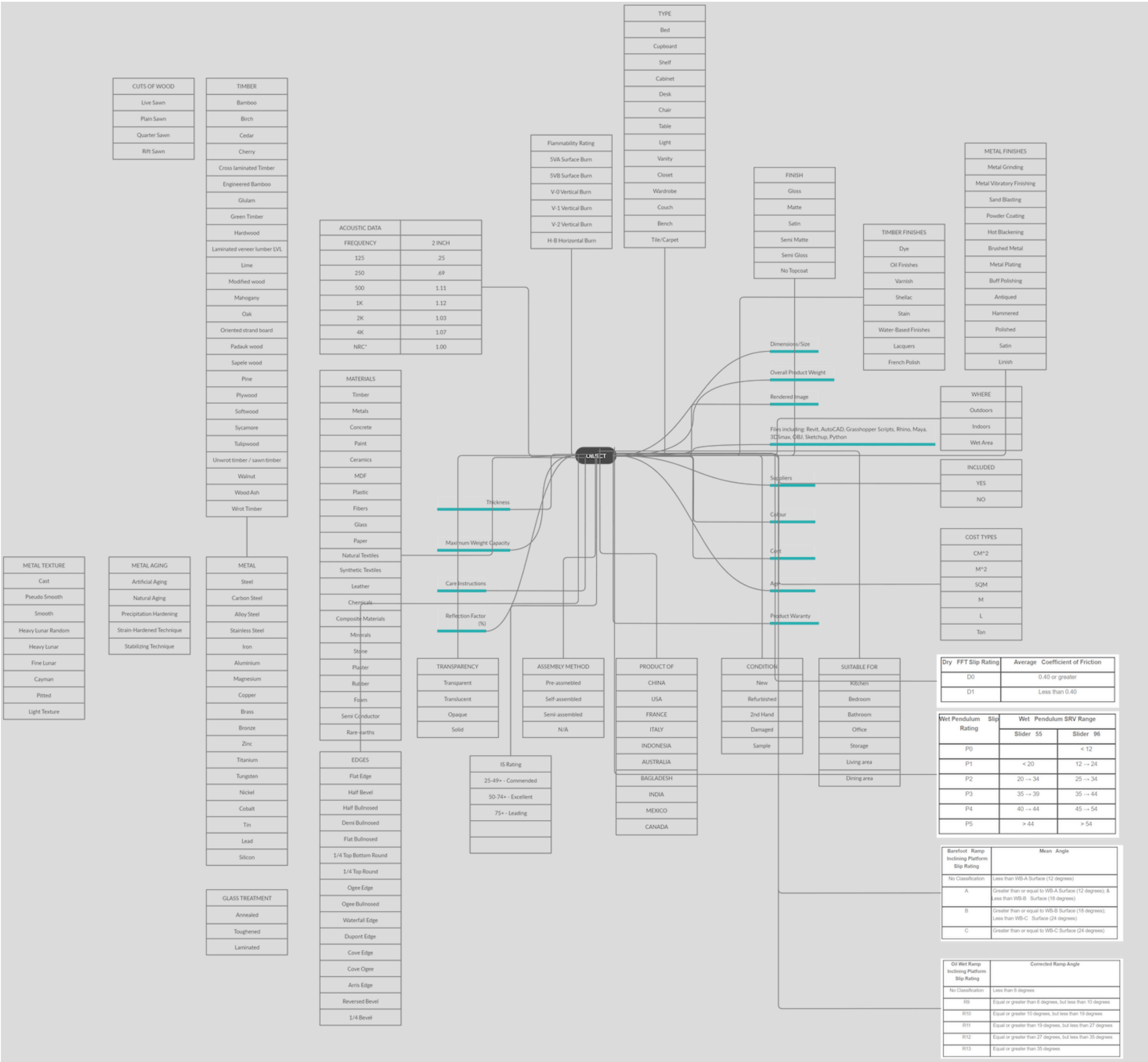
Nonetheless, the relational database is a sufficient tool for testing the thesis material database at a small scale, and hence it is a reliable and dependable tool for testing out the functionality of an online material database.

After deciding on the type of database to use in the project, material properties of an object was determined to ensure all objects can be compared and contrasted. These properties included items referenced in FIGURE 2. The information of objects is stored below shared table values and linked to the object itself. Any objects that might appear in a hotel room is added to the database, this include items such as furniture, paints, stones, metals, timbers, glass and more.

Information is then serialised to convert structured data to a format that would allow it to be shared, stored, and accessed in its original structure.

Overall, this process was successful as research was conducted thoroughly to ensure the material database would be beneficial for designers. The material properties defined would allow designers to input search queries to identify any material, and broad searches can be narrowed down.

FIGURE 2. Image of material database object properties and their table of shared values.

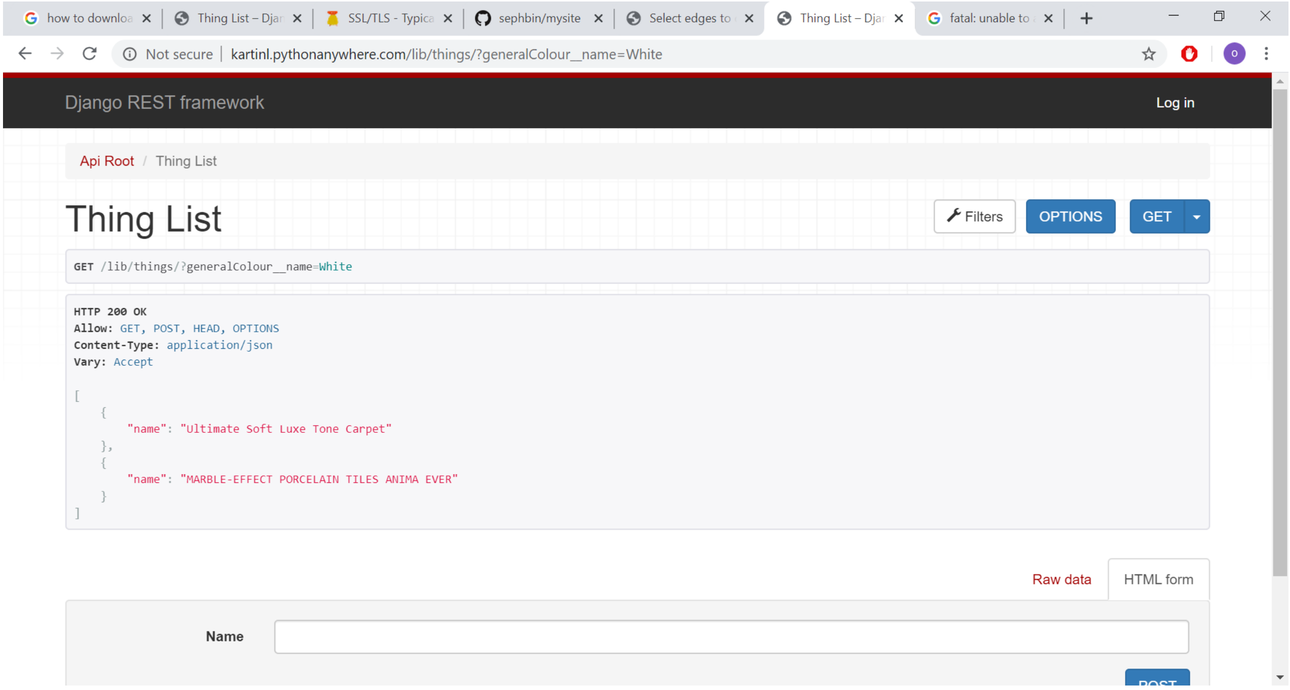


3. TROUBLESHOOTING, DOMAIN HOSTING AND QUERY RETURNS

The application was uploaded onto Github for collaborative access of the code and data. The method that was undertaken to clone the application from the user's local computer to GITHUB was successful, however it was not successful when it came to pulling the database onto another computer. Django-rest filters, which was installed correctly on the local computer, was not compatible with the client's computer. The module SIX was missing, and the term search_query was not found. Extensive research and troubleshooting into the issue was carried out to resolve the problem of missing components and incompatibility. Eventually the following processes stabilised the database. Through updating and reinstalling private utilities within the Django files, updating corsheader in terminal, and deleting several irrelevant items in the Django-rest-frameworks folder, the database was able to function properly again.

The site was then hosted onto a live domain using PythonAnywhere, which allowed for access by users from anywhere around the world. Clients computers are also able to access the material database through GET requests. An API or a search query is given to the database which allows it to return the item or items its seeking as seen in FIGURE 3.

FIGURE 3. Image of GET request on material database.



Overall, the process was successful after troubleshooting and investigating into the issue. It was essential to host the server onto the domain as it would allow for any computer without the application installed to still be able to access the database.

TABLE 2. Table of Data Evaluation Results.

Criteria	Amount of Data	Consistency of Data	Accessibility	Speed	Accuracy
Rating	Poor	Average	Excellent	Fast	Excellent

5. Limitations

1. MATERIAL PHYSICALITY

Many harbours concerns for uploading all materials onto an online database as it robs the designer the opportunity to experience the material. Materials have many physical properties that cannot be experienced digitally including how the light reflects off the surface, how the material feels under heat, how it echos and the feeling it evokes just to name a few. These sensorial experiences are useful predictors of the psychophysical properties of the material. These psychophysical properties are “vital in the design of a product’s haptic interface” (Wongsriruksa, Howes, Conreen and Miodownik, 2012).

2. THE HUMAN READABILITY OF THE MATERIAL DATABASE

Although the server can be accessed through computer coded endpoints, the front end interface is not human user friendly. If a novice designer is hoping to inquire into material choices, they may have a difficult time navigating the barren structure of the site without any guidance or prompts. The server is not easy to use and it takes time to understand how to search for queries.

3. RELATIONAL DATABASE STORAGE CAPACITY

The limitations of a relational database is that it is not the most efficient way of storing data if the material database data expands. Although these issues were not prevalent in the research of the material database at this point due to the minuscule nature of the database, the issues will surface when the data becomes larger. This is important to acknowledge as preventative methods can be implemented to prevent the failure of the system.

6. Evaluation

The work flow for building the application and the software programs used in the project are a efficient way of generating a material database. Python was selected as the sole coding language as it was familiar to the user of the project and it is one of the easiest web development languages to learn for novice coders. Building with Django allows for a streamlined design of the web server, as modifications were easy to be made using the admin page and the files for customisation in the Django project folder. Overall, the investigation into the building of an online material database is a successful and an advancing one. This paper allows for new research into the area to further build upon the interface and stability of this paper's material database.

7. Significance of Project

The significance of the project cannot be undermined as both the process and the approach outlined in this paper revolutionises how designers interact and deals with materials. Although some limitations might restrict the growth of the database and prevent users from interacting with a complicated front end user interface, the method undertaken in this project for storing physical materials online is a new and unexplored area within computational design.

By changing the way designers search, store and select materials, designers will be able to avoid making "wrong choices…which leads to product failures" (Ramalhete, Senos and Aguiar, 2010). This method of storing data allow designers to compare and contrast materials against each other and understand which materials are suitable.

The work flow of this project is also able to be applied to other other complex web based development programs. Django allows novice users to test and simulate a material database, and this can easily be upscaled to a more advanced version using other programs.

Over all, the project highlights the possibility of transposing physical materials for online materials. Although there are many pre-existing online material database, this paper is the only one in the area to utilise a relational database and restful api to conduct material searches. It is also uniquely one of three parts which allows the project to expand and contribute to a bigger area of work within the design industry.

8. Conclusion and Future Work

The project commenced with the idea to utilise an online web server to host a material database. The material database is built with Django using a relational database and restful architecture. Additionally, it was also built with the intent of reducing time, resources and money spent on physical materials and material selection. Although it may be a work in progress, future work might be undertaken to improve the usability of the material database interface. The current interface is mainly for code access, however, for the interface to truly be usable holistic, the interface needs to be machine and human readable at the same time.

A future hope for the material database is for it to work cohesively and collaborative with other parts of the project, and create together a successful automated design process that can create and design interiors.

Ultimately, this paper shows the vast developmental opportunities for the material database within the design industry.

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References

Ashby, M. and Johnson, K., 2014. *Materials And Design*. Oxford, UK: Butterworth-Heinemann.

Colombera, L., Mountney, N. and McCaffrey, W., 2012. A relational database for the digitization of fluvial architecture. *Petroleum Geoscience*, 18(1), pp.129-140.

Hansen, K. and McLeish, T., 2015. *Designing Real Time Sense And Response Environments Through UX Research*. Undergraduate. Vienna University of Technology.

Li, L., Chou, W., Zhou, W. and Luo, M., 2016. Design Patterns and Extensibility of REST API for Networking Applications. *IEEE Transactions on Network and Service Management*, 13(1), pp.154-167.

NAVNEET KUMAR, K., B.K, P., H.L, M. and ASHOK, K., 2016. A REVIEW OF LEADING DATABASES: RELATIONAL and NON-RELATIONAL DATABASE. *i-manager's Journal on Information Technology*, 5(2), p.34.

Nigrelli, G., Chiarle, M., Nuzzi, A., Perotti, L., Torta, G. and Giardino, M., 2013. A web-based, relational database for studying glaciers in the Italian Alps. *Computers & Geosciences*, 51, pp.101-107.

Poustinchi, E., Wang, S. and Luhan, G., 2018. *No Keyboard, No Mouse - Hybrid Digital-Analog Hardware Design For Enhancing Design UI And UX*. Undergraduate. Tsinghua University, Beijing, China.

Ramalhete, P., Senos, A. and Aguiar, C., 2010. Digital tools for material selection in product design. *Materials & Design (1980-2015)*, 31(5), pp.2275-2287.

TOM, P. and GISLI, T., 2018. ENHANCING DESIGN DECISIONS IN MATERIAL SELECTION. *i-manager's Journal on Material Science*, 5(4), p.1.

Wongsriruksa, S., Howes, P., Conreen, M. and Miodownik, M., 2012. The use of physical property data to predict the touch perception of materials. *Materials & Design*, 42, pp.238-244.

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