
Segmentation: Architecture, Construction Management and Engineering (ACE)

Targeting: Architect-engineer

“No challenge poses a greater threat to future generations than climate change” (Barack Obama)

“The building sector contributes up to 30% of global annual greenhouse gas emissions and consumes up to 40% of all energy. Mitigation of greenhouse gas emissions from buildings must be a cornerstone of every national climate change strategy.” [1]

Energy efficiency measures can be taken in all phases in the building life cycle. In the construction phase, which accounts for 10-20% of the energy consumed, the use of recycled content reduces the embodied energy of the building [2]. In the operational phase about 80% of greenhouse gas emissions take place [1]. Heating, ventilation and air conditioning account for most of the energy used in buildings [3].

During the early design phase of a building, many simulations are performed to estimate the energy efficiency of the models. Such simulations can be very time-consuming. Applying machine learning techniques eliminates the need of carrying out a lot of simulations and significantly speeds up early design feedback [2], [3].

Based on the dataset provided by A. Tsanas and A. Xifara through the UCI Machine Learning Repository [4], we are building a real-time predictive analytics application which predicts the heating and cooling load of a building model.

Step (1): We are using the “Energy Efficiency” dataset [4]
Step (2): Predictive modeling using R
Step (3): Real-time predictive analytics application
2. Persona

Name: Scott

Background: 38 years old, married. Master of Architectural Engineering.

Job Title / Role: Architect-engineer

"For me, I would like to..." instantly estimate the energy efficiency of a building model in the early design phase.

MAIN GOALS
Increasing the energy efficiency of buildings. Apply green building standards, design environmentally responsible and sustainable buildings.

PAIN POINTS
Energy simulation is very time-consuming. In the early design phase, many iterations and simulations have to be done.

STAKEHOLDERS
Main persons in contact during work: Architects, project managers.

3. User Experience Journey

<table>
<thead>
<tr>
<th>Mindset</th>
<th>Actions</th>
<th>Touch points</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is on the Persona’s mind while taking the actions of their journey? How do they feel each step of the journey?</td>
<td>What actions and activities does the Persona take while going thru the journey to achieve their goal?</td>
<td>What touchpoints does the Persona have? (Tools, channels, devices, conversations, and so on.)</td>
</tr>
<tr>
<td>There are new building prototypes which have to be analyzed.</td>
<td>Get the BIM data describing the building prototype.</td>
<td>Architect</td>
</tr>
<tr>
<td></td>
<td>Import the BIM data of the prototype into the favorite energy simulation tool.</td>
<td>Energy simulation tool</td>
</tr>
<tr>
<td>This will take some time...</td>
<td>Starting the energy simulation tool.</td>
<td></td>
</tr>
<tr>
<td>Why does it take so much time?</td>
<td>Take a cup of coffee.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate the energy simulation results.</td>
<td>Energy simulation tool</td>
</tr>
</tbody>
</table>

4. Point of View

Scott, the architect-engineer needs a tool to speed up the estimation of the energy efficiency of a building model so that he does not have to spend so much time in carrying out time-consuming simulations.
5. Mockup

The project was published under the link https://standard.experiencesplash.com:443/api/projects/df2e2ed0784ae9da0b9af2a2/prototype/snaps
hot/latest/index.html#/1457130892027_S0

The mockup starts with a launchpad. Click on the left tile with the green building icon.

The following screens have a common process-type icon tab bar:

These steps reflect different phases of the CRISP-DM data-mining process model [5].

Data understanding.
The analysis is based on energy simulations using 12 different building shapes [4].

The building parameters are:
Relative compactness (RC), surface area (SA), wall area (WA), roof area (RA), overall height (OH), orientation (OR), glazing area (GA), glazing area distribution (GD).

The energy efficiency is measured by heating load (HL) and cooling load (CL). These are the “target variables”. We divided the ranges of these variables into five equally-sized classes:

These data are used to build a model which allows us to estimate the energy efficiency of new building shapes.
Explore.
Visualizations can help to detect patterns in the dataset.

We observe that buildings with a large glazing area tend to be less energy efficient (there are more red dots on the right hand side of the scatter plot). This is because glazing is a source of heat leakage [3]. We can visually explore the data by choosing different features for the scatter plot.

Model.
The predictive modeling was done using R. Several different models were trained and evaluated. We ended up with a decision tree model. Decision tree models are robust and perform well for nonlinear data. The model can be visualized using the process flow control in SAPUI5:
The input feature space is successively divided into smaller sub-regions. In the model depicted above, the first split leads to the two subsets \( \{RC \leq 0.75\} \) and \( \{RC > 0.75\} \). For example, if a building model with \( RC = 0.7 \) is given, the upper branch pertaining to the subset \( \{RC \leq 0.75\} \) is selected. At a certain point it does not make sense to split any more. At these end nodes, a linear regression model for the sub-region is provided: ✔ Linear Model

**Score.** This is the main part of the application.

In the upper panel we can change the parameter values by dragging the sliders right or left. When changing one of the parameter values, the score is updated accordingly (“live scoring”). Please note that due to the simple predictive model only few features have an impact on the target variable (heating load). These principal features are shown in bold letters. Moreover, some principal features may be inactive depending on the value of the other ones. Therefore, it may happen that the target variable does not change even though one of the principal features changes.

**Explain.**
The branches which lead to the final prediction are highlighted:

Clicking on a tile shows some detail information, for example the formula of the linear model.
6. Study

Link: https://standard.experiencesplash.com/home/projects/df2e2ed0784ae9da0b9af2a2/research/participant/309098e3a7d47a140ba768f0

Please follow the steps outlined above. It should be possible to go through all of the five steps: Data → Explore → Model → Score → Explain.
Please note that the step “Explain” follows the step “Score”.

7. Developing the SAP Fiori App using SAP Web IDE

Building a real time predictive analytics application involves several steps:

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>(1)</td>
<td>Data acquisition and data/business understanding.</td>
</tr>
<tr>
<td>(2)</td>
<td>Data analysis and model building. We have been using the statistical software environment R to build a decision tree model.</td>
</tr>
<tr>
<td>(3)</td>
<td>Deploy the predictive model as a service, i.e. as a web service which can be invoked in web apps. We have implemented a web service (REST) using the Web API 2 framework and deployed this service to Microsoft Azure.</td>
</tr>
<tr>
<td>(4)</td>
<td>Develop a web application.</td>
</tr>
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</table>

Steps (1)-(3) are not part of the SAP Fiori UX Develop Challenge. Therefore, we focus on part (4).

The SAP Web IDE Project

We started our project “EnergyPerformanceBuildings” from scratch starting with the basic template.

There are only three views in the project, the automatically generated App.view.xml and two application views, BuildingModels.view.xml for the main parts of the application and BuildingModel.view.xml which is a detail view for a specific building model.
Navigation

Navigation between these two application views is performed by the standard routing mechanism: The routes are defined in `manifest.json`.

When navigating from the overview (buildingmodels) to a specific model (buildingmodel), we are passing the building model’s id (mdlId) to the router: (screenshots from SAP Web IDE)

Illustration: Click on row number 4.

Return to the overview page by pressing the button in the upper left corner.
Design components
SAPUI5 provides a rich set of components which are ready to use for the frontend application developer. Besides the plain vanilla controls there are also some quite sophisticated controls like the ProcessFlow or the VizFrame. These are great assets which help us to develop appealing applications.

We have included two of these advanced controls in our app:

- `sap.viz.ui5.controls.VizFrame` for visualizing the BIM data
- `sap.suite.ui.commons.ProcessFlow` for the decision tree model

Two web services have been implemented which provide the data in json format. Only a few lines of code are needed to make use of these amazing controls (see screenshots below).

**Data binding.** The main effort lies in developing web services which provide the data in a format that can be easily consumed by the controls.

**VizFrame:** In our case the data can be explored by changing the measures of the scatter plots. Therefore, the corresponding web service accepts an additional parameter which encodes the selection. For example GAHL stands for Glazing Area / Heating Load.

**ProcessFlow:** This control is primarily intended for visualizing business processes. However, we can also use it for displaying a decision tree. The data model consists of nodes and lanes.
VizFrame: load data, set model.
(screenshots from SAP Web IDE)

ProcessFlow: load data, set model

Give it a try!
http://energyefficiencybuildings.azurewebsites.net/

References
[1] Buildings and Climate Change – UNEP
http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf
http://people.maths.ox.ac.uk/tsanas/Preprints/ENB2012.pdf