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Building Performance Assessment Health Premises Assessment Model

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Abstract: ***Assessment of the performance of a building from the viewpoint of its suitability, improvement, and design needs for people in the hospital is a complex matter. The concerns are beyond measurements of detailed properties of a building, it is more about psychological assessments. As is usual in the built environment, buildings are continually being evaluated to ensure that improvements can be carried out from time to time in the existing building and for new designs. The evaluation is predicated on feedback. The outcomes of the reviews of past building evaluation works indicate that most evaluations are silent on the feedback quality from people with different forms and levels of mental impairments. It is in response to this, and the desire to attend to the aged with age - related cognitive impairment diseases (such as those related to Alzheimer, autism, dementia, and others) that the research motivation emanates. Developing a computational model for the precision assessment of the performance of buildings, in the form of user satisfaction is the aim of this research. The methodology employed for this purpose is anchored on action research through participatory experience and knowledge acquisition of situation via selected case study centers. Descriptively the research exercise entails data acquisition by means of questionnaires supported by literature survey, expert interviews, and observations/experiences, all integrated into a neural networks model. The data gathered were used in analysis and computations to develop the model using an aspect of soft computing techniques - (Fuzzy Neural Networks - FNN). The model is to provide an understanding of the relative importance of the building features taking their simultaneous interrelation into account for the satisfaction of the users in focus.***

Keywords: Neural networks, Health Premises performance, assessment, Satisfaction, Users, and Impairments

1. Introduction

The trend in building performance assessment (BPA) as always is focused on feedback issues in terms of quality and challenges. An overview of BPA is here presented dealing with challenges associated with BPA generally and users' feedback quality specifically. The possible solutions to the challenges are put forward highlighting the place of perception and health in relation to the specific health benefits, feedback capacity, and their effect on data quality. The concern for the well - being of the most vulnerable group, some of them with mild or severe loss of capacity to offer precise feedback, is the motivation for this study. This is to enable us to deal effectively with using their experiences, expectations, and priorities as the basis for offering a dynamic environment. It is important to clarify the meaning of BPA/POE, the plethora of names by which building evaluation is referred, makes this necessary for ease of comprehension. While unavoidably the names are used interchangeably in this paper, the meaning adopted for them all (post - occupation evaluation (POE), building performance evaluation (BPE) Pre - Design Evaluation (PDE), universal performance evaluation (UPE), and building performance assessment (BPA) in this paper is simply 'performance assessment of the built environment in which the users' feedback is central to the outcomes.

Preiser and Vischer (2005) summed up the meaning of Building Performance Evaluation, using the post - occupancy evaluation process model, which was developed by Preiser, Rabinowitz, and White (1988). They explained it as "the process of Systematically comparing the actual performance of buildings, places, and systems to explicitly documented criteria for their expected. Preiser and Vischer (2005) posted that they can be structured according to three levels of performance criteria regarding users need as follows:

Level 1 - Health, safety, and security performance
Level 2 - Functional, efficiently, and workflow performance and
Level 3 - Psychological/social and cultural performance

The General scope of POE are grouped into four:

- Functional performance/technical/environmental performance (health, safety, and security, building services, provisions (heating and cooling; lighting and acoustic, plumbing, and electrical); equipment; materials and information technology provisions.
- Economic Performance - Performance of the building (s) as an investment in resources
- Symbolic Performance - The aesthetic and image characteristics of the building (s) for the society; integration of art and design.

The summary of it all is that building evaluation seeks to understand building performance from the expression of level of acceptance given to it by users.

2. Literature

2.1The Concept of Building Performance and Evaluation

The overall idea of building performance is centered around the concept of use and its effect on human performance. It means that you can evaluate how buildings are performing

through how people perform. Productive, happy, and generally motivated users can be adjudged as being influenced by the environment (building) in which they operate or exist. Specifically, the idea of how buildings and building systems affect the comfort, effectiveness, and well - being of the building user is what defines the relationship between the performance of the users and that of the building itself (Vischer, 2008). To get a good sense of the performance of building systems a complete assessment of the performance of a building is engaged to measure its effectiveness.

Preiser and Vischer (2006) further wrote that the components of the POE paradigm as applied to research on building use have been measuring the level of satisfaction of the users.

The Benefits of POE according to Whyte and Gann (2001) are as follows:

- Applying design skills more effectively
- Improving the commissioning process
- Improving user requirements
- Improving management procedure
- Providing knowledge for design guides and regulatory processes, and
- Targeting of refurbishment

a) POE Process

Zhang and Barrett (2010) also presented a concise summary of the process of POE, the highlight is the overall outcome, which is evidenced based research that could lead to evidenced based design (EBD). Zimring and Reizenstein (1980) listed methods for documenting the design process, for the purpose of feedback database, to include:

- Interview with designers and clients
- Analysis of exchanges between designers and clients
- Designer's walkthrough – Designer walk through the completed design and comment on experience he or she intended users to have in various areas of the projects.
- User's experience measured by interview, questionnaire, direct observations, and others.

b) Building Performance Measurement & Tools

Some of the tools that have been developed for building performance measurement are:

- Building Quality Assessment (BQA)
- Serviceability Tools and Methods (STM)
- Post - Occupancy Review of Building Engineering (PROBE)
- BREEAM award

Van der Voordt, De Been, and Maarleveld (2012) while describing POEs as building - in - use in their studies that focused on intervening in facilities support of different building types, listed the following as the main objectives of POE:

1) The delivery of input to an improvement plan
2) The build - up of generic body of knowledge via the exploration and trials of scientific theories.
3) The development of practical design guidelines and decision support tools.
4) The Challenges Associated with Building Performance Evaluation
5) POE, despite its clear benefits is usually carried out with some risks that tend to serve as drawback, Queensland (2010) listed some of those risks/challenges as:
6) Inadequate definition and management of POE.
7) An undisciplined approach.
8) Invalid or Unreliable data collection.
9) An exclusive focus on negative aspects.
10) Unavailability of participants.

(Turpin - Brooks & Viccars, 2006) said "there is a question of liability as a result of evaluation". To them, POE not being part of the standard procurement processes make designers not feel bound by them.

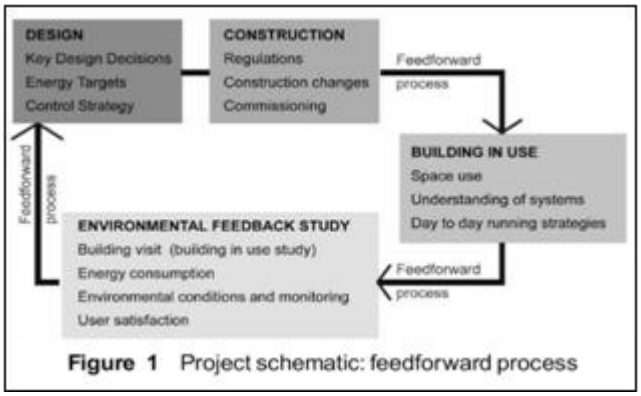

Figure 1: Project schematic: feed - forward process (Andreu & Oreszczyn, 2004)

3. Materials and Approach

3.1 Research Design

Participants

Participants were randomly selected from case study centers; they are users that fit the description of people with cognitive impairments. Overall, about 1000 people were targeted, but a little above 800 people responded by providing feedback according to the questionnaire, part of which is shown in Table 1. About a dozen experts/professionals were interviewed.

3.2 Research Approach

The under listed are the main aspects of the research:

1) Survey/Data Collection
2) Data Analysis,
3) Model Development

3.3 Research Instruments:

The survey/data collection for this research is designed to be collected through the following means:

a) Observations
b) Open ended Interviews
c) Structured Questionnaires

Visit and interaction with people in buildings frequently used by elderly and disabled people shall offer the opportunity to gain insight through observations. This is to

be supported by participatory employment services in such facilities to experience the conditions. This is to serve as a guide in making inferences.

The questionnaire features– sections A - D, a portion of which is presented in Table 1, for the illustration, have five options with value ratings as contained in Table 2.

Table 1: Part of the Questionnaires (Corresponding to Node 11 of the Taxonomy – Fig 3)

S/No.	NT ID No.	QUESTIONS A	Very dissatisfied	dissatisfied	In between	Not dissatisfied	Not at all dissatisfied
	1	Outdoor Environment:					
1	111	Regarding the security of the outdoor environment of your institution, how dissatisfied are you with the lighting conditions provided (considering if there is enough light you feel secure)?	☐	☐	☐	☐	■
2	112	Regarding the security of the outdoor environment of your institution, how much dissatisfied are you with the presence of security personnel (considering if there are personnel you feel secure)?	☐	☐	■	☐	☐
3	113	Regarding the security of the outdoor environment of your institution, how dissatisfied are you with the presence of security monitoring devices (considering if there are enough monitors etc. you feel secure)?	☐	☐	☐	■	☐
4	114	Regarding the security of the outdoor environment of your institution, how dissatisfied are you with the availability of distress call/alarm devices (considering if there are enough distress trigger points, you feel secure)?	☐	☐	■	☐	☐

Table 2: Questionnaire Response Rating Values

Choice Option	Very Dissatisfied	Dissatisfied	In between (Indifference)	Not Dissatisfied	Not at all Dissatisfied
Rated Value	0.1	0.3	0.6	0.9	1.0

The values so obtained are to be fed to each node in the neural tree structure (appendix 2).

As shown above in the abridged questionnaires, answers to questions 111 – 114 and 11 return values 0, 0, 5, 0, 25, 0.25 and 0.25 respectively. These values represent the external input at each node they are used with the activation and transfer functions for network training and general analysis.

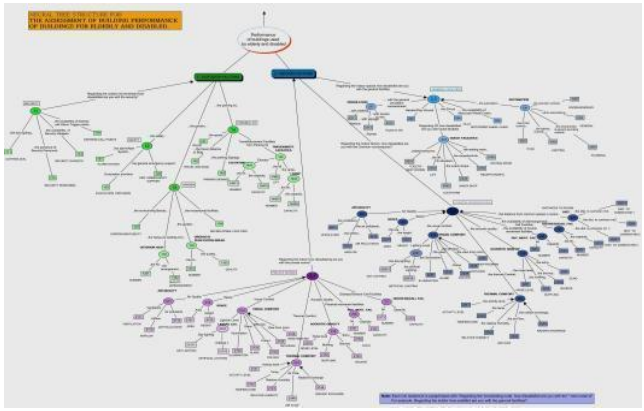

Figure 2: Architecture of model

A. Model Development using - Neural Computation Method

The rated values, as shown in table 2, obtained from the questionnaires, will be clustered and then used as weights w_i. The overall concept of the use of this computation method, is the core element of this research, and it is derived from fuzzy set theory focusing on radial basis function (RBF).

Suffice it to say, at this stage of the research, that the following Gaussian activation and transfer formula are to be used to iteratively obtain both input and output values for nodes in a feed forward and back propagation fashion, where appropriate, to target the desired overall output with minimum internal errors, for a general analysis and model development. This stage of the research is envisaged undertaken after data collection:

$$f(X) = w\phi(\| X - c \|^2)$$

$$O_j = \exp(-\frac{1}{2}\sum_i^n \left[\frac{(w_i - I)}{\sigma_j / w_{ij}}\right]^2)$$

Where j is the layer number; i denotes the i - th input to the node; w_i is the degree of membership at the output of the terminal node; w_{ij} is the weight associated with the i - th terminal node and the non - terminal node j. The width of the basis function σ is used to measure the uncertainty associated with the node inputs designated as external input X. The output of i - th terminal node w_i is related to X by the relation $X_i = w_i w_{ij}$, where w_{ij} is the weight connecting terminal node i to terminal node j. It connects the output of a basis function to a node in the form of an external input. The centers of the radial basis functions are the same as the input weights of that node, w_{ij}.

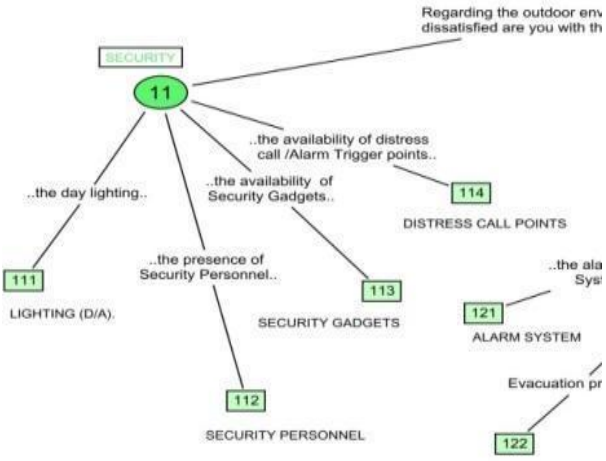

Figure 3: Node 11 of the from the Tentative Taxonomy (Fig.2.)

Referring to figure 3 $f(x)$, abridged from the tentative model structure, is equal to the output expected at the final point, node 11, *i s* are nodes 111, 112, 113, and 114, they are all terminal nodes, j is node 11, a non - terminal node, for this segment of the structure, n = 4, as shown next page, the important parametric values of w_i, w_{ij}, c_i and σ, are to be determined in the Gaussian processes involving iterative neural structure training and retraining until when errors are reduced to minimum and the desired values, based on objective functions are achieved.

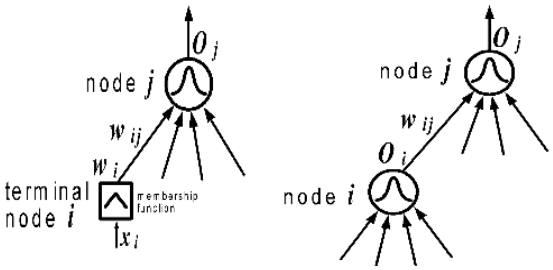

Figure 4: The detailed structure of a neural tree with respect to different type of node connections

4. Results and Discussions

Datasets, computation algorithm, computation values and outcomes.

The results are in two parts, one is the datasets obtained from the survey. Part two is the model development using the obtained datasets as seen above in figure 2.

a) The Actual Data Set (S)

Data feeds obtained from surveys logged in the database tagged BPA Assessment database, a view of which is shown in Fig.2.

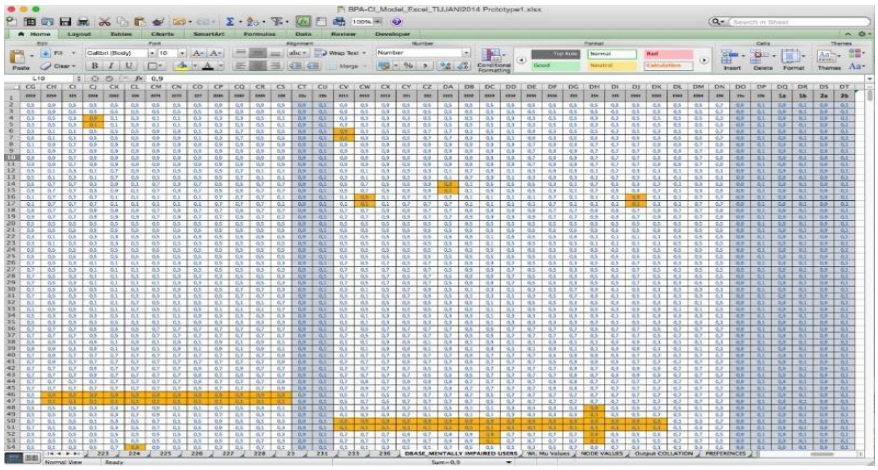

Figure 2: Database for Actual Computation

b) Solution to the challenges

As a solution, Way and Bordass (2005) recommended what they call soft landing, an approach that provides the avenue for designers and builders to achieve all - round benefits, to all key stakeholders - the client, users, and themselves (Leaman & Bordass, 2007). To improve on the communication between designers and users, (Shen, Shen, & Sun, 2012) propositioned the modification of BIM to UASE – user activity simulation and evaluation method, to achieve the following main gap filling objectives:

- To improve user's understanding on the design, also it helps them to specify their activities in the given new building, thus increasing their involvement in the communication with designers.
- To carryout pre - occupancy evaluation of the design in terms of spatial properties, thereby enabling the collection of user feedback of or on the design.

5. Conclusions, Recommendations and Future Work

A. Conclusion

In conclusion, the research objective of developing a decision support system for the extraction of useful knowledge from imprecise user - feedback data has been achieved. The fact that at this point in the research process there now exists a building performance model (BPA - CI Model) for use in building performance evaluation in circumstances where the feedback quality is in doubt – such as is the case with users suffering from mental challenges.

It was specifically established that there exists enough evidence to show the built environment has influence and generally impact on health outcomes. The fact that feedback from building users with various forms of mental

impairments was not adequately paid attention and factored into building evaluation was also established, thus leaving gaps in the completeness of basis upon which design, improvement and facilities management decisions are premised. The fact that most of the elderly who now suffer from mind and memory compromising ailments were healthy enough to know and demand certain level of performance from buildings motivate the need to keep tendering to those expectations even when they can no more express the same precisely.

Consequent to the robust survey and experience gathering exercises, the data collected from them were processed using computational intelligence (CI) technique – Fuzzy Neural Networks (FNN) to develop the building performance assessment (BPA) model which was implemented by test running to validate the efficacy.

B. Recommendation and Future Work

The developed model (BPA– CI) though simplified can further be made simpler if entries and collation are automated. It is recommended that responses from categories of users should be spread over a long time so that they are in the form of log entries, each entry are updated as they become available. An online version of the Questionnaire needs to be in appropriate languages and available for filling.

It is recommended that in line with each feedback questions contained in the Questionnaire, the enquiries should be socialized, and responses demanded in as friendly as possible way (s). Depending on the severity of the mental impairment, proportionate time should be taken to log in the responses to reduce fatigue in answering questions. Direct caregivers of the users can be relied upon to give possible answers based on their knowledge of the respondent (s).

It is recommended that the model should be adopted and developed into an assessment application software tool for competition amongst equal institutions to encourage improvement amongst peers.

Generally, further research shall be carried out, collaborating with a human mood and emotion perception - imaging laboratory, to develop automated sensor/device driven users' feedback

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