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Parametric Optimization of Hospital Design

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***Abstract*—**Present paper presents a parametric performance-based design model for optimizing hospital design. The design model operates with geometric input parameters defining the functional requirements of the hospital and input parameters in terms of performance objectives defining the design requirements and preferences of the hospital with respect to performances. The design model takes point of departure in the hospital functionalities as a set of defined parameters and rules describing the design requirements and preferences.

***Keywords*—**Architectural Layout Design, Hospital Design, Parametric design, Performance-based models.

I. Introduction

ARCHITECTURE and engineering has throughout history developed according to available technology and materials. One of today's technologies and materials is the computational capacity. Applying computational capacity in the design process allows emerging design types, where computation and handling of complexities is facilitated by computational power. Architecture has been through a transformation from manually driven tool-based design in terms of pen and paper to digitally driven form-based design through computer use and global practices [1]. The processes are opening up new territories for conceptual, formal and tectonic exploration, where architecture and architectural morphology is articulated using generative processes enabled by various analyses and simulations, shifting the emphasis from making of form to finding of form [2]. Finding of form is the process, where form derives from the processes of discovering and editing based on analysis, where making of form is the process of inspiration and refinement. The performance-based design models driven by simulations through generative processes are one of the new architectural territories based on finding of form from a set of performance requirements.

There exists a wide range of simulation and analysis tools for evaluating performance perspectives. However integration of simulations into the generative processes is still to be further developed. Current practice is dominated by integrated design, which operates with analytical simulations in the design process, and the design is modified through a process of design development and simulations. Performance-based design distinct from current practice, as results of analysis and simulations directly modify designs; performance-based design is based on the ability to directly act upon the physical performance properties of the specific design [3]. By the performance-based models it is possible to achieve a higher level of sustainability, as the behaviour and performance capacity arises from the processes of self-organisational systems, whereby materials and material systems can be conditioned accordingly [4]. Objects are generated by simulating their performances, and design is defined and characterized by applying digital simulations of external forces to drive form generation [3]. The contemporary architectural design approach utilizes digital technologies of quantitative and qualitative performance-based simulation, spreading multiple realms from spatial, social and cultural to purely technical structural, thermal, acoustical, etc. [5]. Performance-based design is not merely devising a set of practical solutions to a set of largely practical problems as a neo-functionalistic approach [5]. It differs from the modernist functionalism as the theme of performance is the key to the building's internal definition or pre-predicated existence. It is meta-narrative with universal aims that are dependent on particular performance-related aspects of each project [5]. The emphasis shifts from the buildings' appearances to processes of formation grounded in imagined performances, indeterminate patterns and dynamics of use, and poetics of spatial and temporal change. It has the potential to produce an effect at any moment in time. The mechanisms of performativity are nomadic and flexible instead of sedentary and rigid. Spaces are networked and digital rather than enclosed, and its temporalities are polyrhythmic and non-linear [6].

Parametric models are one construction of an operative method to work with Performance-based models as the parametric models define the method of generating architecture based on a set of rules, structures or parameters. The design process is an iterative process, where design is generated on basis of the chosen parameters and performances, where parameters, performances and interdependencies are iteratively evaluated and variation are generated. Variations can easily be transformed by activating and adjusting the prescribed relationships. According to Oxman the parametric design process is formational rather than compositional and formal; manipulation of associative geometrical relations of complex structural patterns becomes spatial concepts of the complexity of heterogeneous structures [3]. The parametric concept facilitates changes in parameters or content; and the individual members of the content respond uniquely to the changes [7]. During the design process, the partial descriptions of the design, the design requirements and preferences are present meanwhile allowance for evolvement according to the process is present. An enlarged set of

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performances is integrated in the design and assessed in the early stages, which enhances interdisciplinarity and reduces poor performing solutions for the final result. The parametric model advocates functional integrated solutions for architectural form with point of departure in the approach, that inspiring architectural form arises of functional requirements with a corresponding arrangement of all parts of the building present simultaneously [8]. Combining architectural, engineering and functional perspectives is the essence that creates the synthesis from the conceptual design phase. Functional requirements as building performances are a central element in architectural layout design and configuration, concerned with finding of feasible locations and dimensions for a set of interrelated rooms that meet all design requirements, meanwhile the design quality is maximized in terms of design preferences. Architectural layout design is closely related to spatial configuration, to which several proposals have been given during the last decades [9-19], with focus perspectives of component packing [20-23], route path planning [24, 25], and process and facilities layout design [26-31].

The performance-based parametric model is a design approach applicable for design problems related to complex layout designs with several requirements and preferences as present in hospitals. The complexity of the building typology necessities focus on functionalities and bonds to achieve highly functional performances of the primary hospital functionalities of diagnostics, treatment and care, to avoid wastes in terms of short supplies, queues and delays, bottlenecks, waste of resources, long lengths of stays, low level of productivity, inappropriateness of clinical settings and workload variability. Layout design in terms of hospitals is highly relevant to achieve well-performing hospitals driven by the hospital performances, meanwhile logistic flows are structured and managed in terms of route path planning, and process and facilities layout planning parallel to [26-31].

Though, hospital design is very complex in its ontology of a complex building typology with various performance perspectives as requirements and preferences. The parametric model is applicable, as it facilitates a geometric approach to handle the complexities by a set of defined parameters and rules.

Present paper presents a model for optimized hospital design based on a parametric design model including several performance simulations coping the widespread design requirements and preferences of a hospital. The aim of the model is optimized hospital design and a facilitated design process where the building attributes and interconnectivities are visualized and formally described.

II. Methodology

A. The Parametric Design Model

The parametric model as part of the performance models containing parametric descriptions of formal behavior through bottom-up processes, thus structures are shaped and formed based on various criteria. It is a process where several parameters define the cornerstones and the starting points, and the design emerges as alternates defined by a given set of parameters. It is finding form out of a set of parameters by extracting the problem; define it, define the boundaries, the starting points and the requirements. Solutions to the problem are reached within the boundaries or design alternatives are produced with freedom to research and produce alternatives to the boundaries, restrictions and requirements. The emphasis is performance over appearance and on processes over representation [32] .

The design model is developed through a procedure, where aesthetic, functional and technical requirements drive the processes, and the layout performances are concerned with finding of feasible locations and dimensions for a set of interrelated rooms and functions.

The parametric model consists of a hierarchical structure applicable for formal design problems, where principal parameters are identified and structured as the highest level of the hierarchical structure. The principal drivers capture the semantics of the design and are arranged corresponding the demography and external relations defining the need for treatment and thereby the need, dimensioning and definition of the primary hospital functionalities. The parameters defining the design consist of geometric units and performance objectives as input parameters.

Fig. 1 Building Typologies for Hospital Design

The highest level in the hierarchical structure includes the building typology, as illustrated in fig. 1, applicable at the given site as a combination of the geometric units and performance objectives with respect to the external relations. The building typology refers the external relations in the available site, the relations to the surroundings and the cultural understanding of a hospital as a building, meanwhile the typologies form the basis for design alternates.

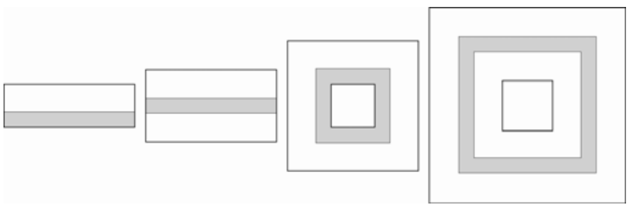

Fig. 2 Section Typologies for Hospital Design

Parallel to the building typology at the highest hierarchical level in the design model are alternates for section typologies, as illustrated in fig. 2, for layout organization referring geometric units and performance objectives in terms of internal relations, cultural background and hospital procedures, generating a level of design alternates with different performances.

TABLE I
THE HIERARCHICAL CONSTRUCTION OF THE PARAMETRIC DESIGN MODEL

Principal drivers→	Intermediate construction→	Resulting geometry
	Input parameters	
External logistics Demography	Need for treatment as Performance Objectives and Geometric Units	Design Concept

Table I outlines the hierarchical construction of the parametric design model, with building typology and section typology as elements of the principal drivers, and the design modeling within the intermediate construction, where geometric quantities and qualities and the bindings in-between are defined. The intermediate constructions link the principle drivers to the resulting geometry and create the apparent geometric behavior of the design.

Structuring a problem by the hierarchical parametric model defines the specific configuration of the intermediate construction by the principal drivers to support and respect the defined constraints and possibilities. For the hierarchical design model, it is essential to maintain flexibility, allowing changes in the configuration and behavior of the intermediate construction and parameters. It is a necessity initially to identify the primary drives with highest impact factor and most decisive for the design.

The intermediate construction describes the functionalities in terms of logistics or bonds, and capacities, qualities and times, define the data for the intermediate construction linking the principal drivers to the resulting geometry. The resulting geometry is the simulation of the geometric design objectives, which are defined on local basis relating the global structure. The resulting geometry derives from the intermediate construction as variable layout designs simulated by general non-linear optimization problems by cost objectives. The applicability of the optimization methods relies on the parametric construction of the design model, and the layout designs defined by the model, arise functional integrated solutions for architectural form where a corresponding arrangement of all building attributes is present.

The intermediate construction contains two main input parameters, the geometric parameters as a dimensioning and definition of the needed hospital functionalities based on the principal drivers and the performance objectives as the input parameters defining the required performances of the hospital functionalities likewise defined by the principal drivers.

B. Geometric Units as Input Parameters

The need for treatment and dimensioning thereof defines the room programme for the entire hospital based on the specializations of the hospital and the demography. The room programme defines the in parameters for the geometric units of the hospital as reflections of the need for treatment and thereby the functional requirements for treatment and care.

The geometric units are thus derived from the principal drivers as the needed functionalities in geometric terms, meanwhile the performance objectives are derived from the principal drivers as the parameters defining the measures of performances to be incorporated to achieve well-performing hospitals.

C. Performance Objectives as Input Parameters

The performance objectives are functions covering the various performance objectives of a hospital given by the principal drivers. The functions are formulated to drive the design of the hospital through sub-functions of design requirements and preferences.

TABLE II
PERFORMANCE OBJECTIVES OF THE PARAMETRIC MODEL

Operating costs
min $f_{opcosts}(x)$ *s.t.* $h_{opcosts}(x) = 0$ $g_{opcosts}(x) \leq 0$ x in R_n
Hospital procedure
max $f_{hospproc}(x)$ *s.t.* $h_{hospproc}(x) = 0$ $g_{hospproc}(x) \leq 0$ x in R_n
Patient procedure
max $f_{patiproc}(x)$ *s.t.* $h_{patiproc}(x) = 0$ $g_{patiproc}(x) \leq 0$ x in R_n
Hospital flexibility
max $f_{hospflex}(x)$ *s.t.* $h_{hospflex}(x) = 0$ $g_{hospflex}(x) \leq 0$ x in R_n
Healing surroundings
max $f_{healing}(x)$ *s.t.* $h_{healing}(x) =0$ $g_{healing}(x) \leq 0$ x in R_n

The performance objectives are arranged into five performance functions as outlined in table II, where x is the function of design variables, n is the number of variables, and $h(x)$ and $g(x)$ are functions of equality and inequality constraints. The respective performance objectives are the generative drivers of the intermediate construction that correspond the geometric units and define the design concept for the layout organization according to the hierarchical structure of the design model as outlined in table I.

1. Minimizing Operating Costs

Each performance objective consists of several sub-objectives defining design requirements and preferences.

The functions for minimizing operational costs or optimizing the operational cost performances are restricted to the costs for operating the building caused by the building design and building design choices.

TABLE III
MINIMIZING OPERATING COST

f(x)=Personnel(x)·w$_i$*(x)+Functional(x)·w*$_{ii}$*(x)+Buildingop(x)·w*$_{iii}$*(x)*		
Personnel costs, *Personnel(x)*		
Local Transportations(x)	*P(A)*	Function for local transportations relating, distances, shifts and personnel groups of a given room x in the local relation within the section.
Global Transportations(x)	*P(B)*	Function for global transportations relating, distances, shifts and personnel groups of a given section x in the global relation within the building / to other sections.
Local Accessibility(x)	*P(C)*	Function for the local accessibility of a given room x in the local relation within the section.
Functional Costs, *Functional(x)*		
Special Functionalities(x)	*P(D)*	Function for a given room x with 'special' functionalities defining the requirements to the relating rooms.
Local Deposits(x)	*P(E)*	Function for the relationship to local deposits for a given room x within the section.
Global Deposits(x)	*P(F)*	Function for the relationship to global deposits for a given section x within the building.
Building Operating Costs, *Building op(x)*		
Building Surface(x)	*P(G)*	Function of the building surface area x as a building envelope with energy loss and contribution.
Energy Utilization(x)	*P(H)*	Function for the energy utilization x caused by the overall building design.
Distance Installations(x)	*P(I)*	Function for the installation distances x caused by the overall building design.
Building Consumptions(x)	*P(J)*	Function of the energy consumption x of the overall building design.
Design requirements and preferences		
Section Definition(x)	*P(K)*	The conditions for the section definitions given local transportations, local accessibility and local deposits.
Section Arrangement(x)	*P(L)*	The conditions for the section arrangement given global transportations, special functionalities, global deposits and energy utilization.
Building Proportions(x)	*P(M)*	The conditions for the overall building proportions given the building surface, distances for installations and building consumptions.
Operating Costs(x)	*P(N)*	Conditions for the operation costs of the building caused and dependent by the overall building design.

The performance objective contains categories of personnel costs, functional costs, and building operating costs as sub-objective outlined in several functions (*P(A)-P(J)*) in table III. These derives the design requirements and preferences in *P(K)-P(M)* for the definition and arrangement of the sections according to each other closely related to the section typology and the dimensioning of the overall building proportions closely related to the building typology. Finally *P(N)* outlines the overall hospital design requirements and preferences with respect to operating costs.

The relations from sub-objectives to design requirements and preferences relate different sub-performances to each other to describe and define the conditions for design guides to section definition *P (K)*, section arrangement, *P (L)* and building proportions, *P (M)* through personnel routes, *P (A)-P(C)*, supply routes, *P (D)-P (F)*, and placement of functions with special requirements of use, *P (H), P (I)*.

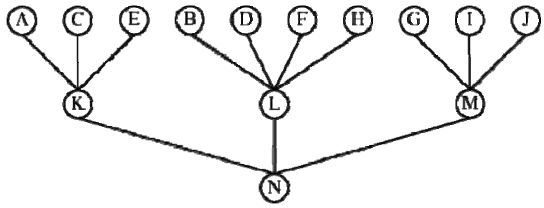

Fig. 3 The relations from sub-objectives (A-J) to design requirements and preferences (K-M) with respect to a given performance objective (N)

2. Improving Hospital Procedure

The performance objective of 'Hospital Procedures' consists of sub optimization objectives of patient safety and physical working environment defined as respectively hygiene, acoustics, light and workspace.

TABLE IV
IMPROVING HOSPITAL PROCEDURE

f(x)=Hygiene(x)·w$_i$*(x)+Acoustics(x)·w*$_{ii}$*(x)+Light(x)·w*$_{iii}$*(x)+Workspace(x)·w*$_{iv}$*(x)*		
Hygiene, *Hygiene(x)*		
Cleanliness(x)	*P(A)*	Cleanliness-function of a room x in relation to other rooms.
Transmission: room-room(x)	*P(B)*	Function for risk of room to room transmission of a given room x in relation to other rooms.
Acoustics, *Acoustics(x)*		
Noise separation(x)	*P(C)*	Function for noise discomfort of a given room x in relation to other rooms, relating noise generated in the given room x and other rooms, inconvenience of noise transmission and protection of sensitive information.
Privacy(x)	*P(D)*	Function for privacy of a given room x relating sound absorption and insulation.
Light, *Light(x)*		
Daylight(x)	*P(E)*	Function for the daylight conditions of a given room x.
View(x)	*P(F)*	Function for the view conditions of a given room x.
Orientation(x)	*P(G)*	Function for the orientation conditions of a given room x in relation to the corners of the world.
Workspace, *Workspace(x)*		
Proportions(x)	*P(H)*	Function for the workspace proportions and room demands for a given room x.
Design requirements and preferences		
Section Arrangement(x)	*P(I)*	The probability of room order given cleanliness, transmission: room-room and noise separation.
Room Proportions(x)	*P(J)*	The probability of room proportions given privacy, view and proportions.
Orientation(x)	*P(K)*	The probability of orientation given daylight, View and orientation.

Hospital Procedure(x)	*P(L)*	Probability for hospital procedures given room order, room proportions and orientation.

The performance objectives are outlined in *P(A)-P(H)*in Table IV defining the sub-performance objectives. These derives the design requirements and preferences in function *P(I)-P (K)* defining the overall hospital design requirements and preferences with respect to hospital procedures. Section Arrangement, *P(I)* and Room Proportions, *P(J)* are closely related to the input of the principal drivers of section typology, whereas Orientation, *P(K)* relates both to room placement within the sections but also the overall orientation of the building mass related to the building typology.

3. Improving Patient Procedure

Improvement of patient procedures includes categories of patient transportation, distances and patient shifts, whereas patient and patient procedure are in center and route path planning around patient procedures defines the variables.

TABLE V
IMPROVING PATIENT PROCEDURE

$f(x)=PFocus(x)\cdot w_i(x)+CareContinuity(x)\cdot w_{ii}(x)+CareHealroom(x)\cdot w_{iii}(x)$		
Patient focus, *PFocus(x)*		
Privacy(x)	*P(A)*	Privacy function for a given room x in relation to other rooms.
Individualism(x)	*P(B)*	Function for the individuality of a given room x in relation to other rooms.
Relatives(x)	*P(C)*	Function for relative accessibility and room for relatives in a given room x.
Continuity of care, *Care Continuity(x)*		
Independence(x)	*P(D)*	Function for the patient's independent ability to accomplish treatment and care (without company necessity of personnel or relatives). The function is for a given room x in relation to other rooms.
Personnel(x)	*P(E)*	Function for proximity of personnel and continuity of personnel for a given room x.
Professionalism(x)	*P(F)*	Function for providing the framework of a professional and individual treatment in a given room x by the room itself and in relation to other rooms.
Room for care and healing, *Care Heal room(x)*		
Accessibility(x)	*P(G)*	Function for the accessibility to a given room x.
Way finding(x)	*P(H)*	Function the wayfinding to a given room x for the related patients, inpatient, out-patient or emergency.
Rehabilitation(x)	*P(I)*	Function for the rehabilitation conditions in a given room x.
Design requirements and preferences		
Patient route(x)	*P(J)*	The conditions for the patient route given accessibility, wayfinding and independence.
Comfort	*P(K)*	The conditions for patient comfort given privacy, professionalism and individualism.
Care(x)	*P(L)*	The conditions for patient care given rehabilitation, relatives and personnel.
Patient Procedure(x)	*P(M)*	Probability for patient procedures given Patient route, comfort and care.

The performance objectives are outlined in *P (A)-P (I)* defining the sub-performance objectives. These derives the design requirements and preferences in *P (J)-P (L)* defining the overall hospital design requirements and preferences with respect to patient procedures. All design requirements and preferences with respect to patient procedures, *P (J)-P (L)* are related to the section typology of the principal drivers.

4. Improving Hospital Flexibility

Improvement of hospital flexibility includes categories of grouping related functions, load-bearing cores and flexibility in facades and rooms, standardization of rooms, and preparation for changes.

TABLE VI
IMPROVING HOSPITAL FLEXIBILITY

$f(x)=Accessibility(x)\cdot w_i(x)+Standardization(x)\cdot w_{ii}(x)+Functionality(x)\cdot w_{iii}(x)$		
Accessibility, *Accessibility(x)*		
Local Accessibility(x)	*P(A)*	Function for the local accessibility to a given room x.
Global Accessibility(x)	*P(B)*	Function for the global accessibility to a given room x.
Universal Accessibility(x)	*P(C)*	Function for the universal accessibility to a given room x.
Standardization, *Standardization(x)*		
Standard Rooms(x)	*P(D)*	Function for the standardized measures of a given room x.
Functionality, *Functionality (x)*		
Functionality(x)	*P(E)*	Function for the functionality of a given room x independent of the surrounding rooms.
Treatment(x)	*P(F)*	Function the treatment specific conditions of a given room x.
Design requirements and preferences		
Technology(x)	*P(G)*	The conditions for how preparedness for technology is incorporated given accessibility, standard rooms and functionality.
Reconstruction(x)	*P(H)*	The conditions for preparedness for reconstructions given local, global and universal accessibility, and standard rooms.
Demography(x)	*P(I)*	The conditions for incorporation of regulations in demography given standard rooms, universal accessibility and functionality.
Hospital Flexibility(x)	*P(J)*	Probability for hospital flexibility given Technology, reconstruction and demography.

The performance objectives are outlined in *P(A)-P(F)*defining the sub-performance objectives. These derives the design requirements and preferences in function *P(G)-P(I)* defining the overall design requirements and preferences with respect to hospital flexibility. The design requirements and preferences of hospital flexibility relates the intersection og building typology and section typology as hospital flexibility is about the preparedness for changes, which lies in the essential construction of the hospital building mass described by the principal drivers.

5. Improving Healing Surroundings

Improvement of healing surroundings includes categories of engender to safety, patient safety, natural lighting, view and green surroundings, acoustics, and rooms encouraging rehabilitation.

TABLE VII
IMPROVING HEALING SURROUNDINGS

f(x)=Safety (x)·w$_i$(x)+NaturalSet(x)·w$_{ii}$(x)+Rehabilitation(x)·w$_{iii}$(x)		
Safety, *Safety(x)*		
Local Safety (x)	*P(A)*	Function for hospital instills confidence and safety for patient by the local arrangement of rooms for a given room x.
Global Safety(x)	*P(B)*	Function for hospital instills confidence and safety for patient by the global arrangement of rooms for a given room x.
Natural Settings, *Natural Set (x)*		
Natural Lighting(x)	*P(C)*	variable for natural light as a healing element
GView(x)	*P(D)*	variable for view and green elements as a healing element
Rehabilitation, *Rehabilitation(x)*		
Acoustics (x)	*P(E)*	variable for acoustics as a healing element
Activity(x)	*P(F)*	Function the activity motivation conditions of a given room x.
Design requirements and preferences		
Orientation(x)	*P(G)*	The conditions for the patient route given accessibility, wayfinding and independence.
Section Arrangement(x)	*P(H)*	The probability of room order given engendering to safety based on condition for patient comfort and safety.
Accessibility/Decoration (x)	*P(I)*	The conditions for patient care given rehabilitation, relatives and personnel.
Healing Surroundings(x)	*P(J)*	Probability for patient procedures given Patient route, comfort and care.

The performance objectives are outlined in *P (A)-P (F)* defining the sub-performance objectives. These derives the design requirements and preferences in *P (G)-P (I)* defining the overall hospital design requirements and preferences with respect to healing surroundings. The design requirements and preferences relates primarily to the section typology of the principal drivers, as the healing surroundings are more patient related and thereby primarily in scale of the sections.

III. DEMONSTRATION EXAMPLE

A. Implementation Issues

The performance-based design model is based on a iterative process, where the cost-value of the sub-performance objectives initially can be defined as constraints, moreover it is possible to calculate the cost-values as a derivative of the design alternates. The parametric model generates by the mathematic formulation of the performance objectives and the geometric units the basis for handling hospital layout design with an optimization perspective according to the definition of the performance-based design model. The optimization perspective is inherent in the mathematical formulation of the performance objective functions, an essential driver in the process of finding the best location and size for the geometric units. The hospital design is thus constructed by the geometric units and the performance objectives as a set of defined parameters and rules. The resulting geometry is thus the reflection of the performance objectives and the geometric units. The performance objectives drive by the sub-performances the design requirements and preferences.

B. Mathematical Description of Room Distribution

The basis of present parametric design model is based on a mathematical description of the room distribution according to the principal drivers. The rooms to be distributed are a result of the need for treatment defined through the intermediate construction.

High Rise
Building typology

Interior Hall, Rectangle
Section Typology

Fig. 4 The exemplification of the room distribution is based on the High Rise Building Typology and Interior Hall, Rectangle Section Typology as the principal drivers

Rooms are distributed by a function *f(x)*, according to the section typology and building typology, defining the baseline x_i. A distribution function based on *i*. *x(i)*defines the positioning of each room according to fig. 2 below. This physical framework is the essence of the room distribution according with minor variations according to the respective building typologies and section typologies.

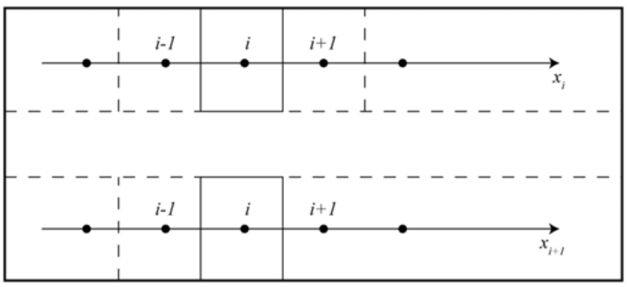

Fig. 5 Physical framework for room distribution through functions of *x(i)*. *x(i)*is the room *x* in position *i*, which is distributed by a function.x_i is the baseline *i* is distributed on

With point of departure in the geometric units as input parameters in terms of a room program, as a response of the need for treatment, the layout design for a hospital design is exemplified in the following.

C. Exemplifications

The room distribution is dependent on the performance-objectives, as several performances are related to the positions of the rooms. Thus relativity exists between the functions for design requirements and preferences and the room distribution function. The room distribution emerges through iterations of the various performance objectives and their relative design requirements and preferences. In the following, the transmission function, as part of the hospital procedures will be exemplified, as this function entails relativity to the room distribution.

$$Transmission(x) = RiskofTransmission(x) \cdot RiskbyTransmission(x) \quad (1)$$

RiskofTransmisison(x) is a function of the risk of transmission to a given room x. *RiskbyTransmission(x)* is therisk by transmission for at given room x. This risk relies on the cleanliness function of the given room, as the risk by function combines the requirements to cleanliness and the actual cleanliness in a given room x. To compute *RiskofTransmisison(x)* several functions regarding the position and type of the given room x and the nearby rooms must be defines, as the *RiskofTransmission(x)* is an expression of a room to room transmission.

$$T(i,xi) = T(i-1,xi)T(i+1,xi)T(i-1,xi+1)\,T(i,xi+1)T(i+1,xi+1) \quad (2)$$

$$T(i,xi) = T(i-1,xi)T(i+1,xi)T(i-1,xi+1)\,T(i,xi+1)T(i+1,xi+1) \quad (3)$$

$$T(i,xi) \neq T(i-1,xi)T(i+1,xi)T(i-1,xi+1)\,T(i\;xi+1)T(i+1,xi+1) \quad (4)$$

$$T(i,xi) = T(i,xi+1) \quad (5)$$

T(i,x_i*)* is the type function of a given room x in position i as illustrated in Fig 2. x_i is the baseline i is distributed on.

The transmission function *Transmission(x)* part of the sub-performance objectives of hospital procedures, is a as sub-performance implying in the design requirements for section arrangements and thereby the placement of rooms according to each other in a given section.

TABLE VIII
TRANSMISSION(X)

P(B)		
Transmission (x)=RiskofTransmission(x)·RiskbyTransmission(x)		
RiskofTransmission(x)		*RiskbyTransmission(x)*
Risk for transmission		Risk by transmission
f(x)=	for *x(T(i)), T(i)* is the type function of the room *x* in position *i*.	f(x)=Cleanliness(x), for all x.
0	If Eq. 2 is true.	
0,25	If Eq. 3 is true four times.	
0,5	If Eq. 3 is true three times.	
0,75	If Eq. 3 is true twice.	
0,9	If Eq. 3 is true once.	
1	If Eq. 4 is true.	
1	If Eq. 5 is true.	

The operator for the combined transmission function, *RiskofTransmission(x)* depends on the type of room and the positioning thereof, where *RiskbyTransmission(x)* depends on *Cleanliness(x)* depending on the type of room, *T (i)*.

A matrix of the sub-performances of the hospital procedures is illustrated in Table IX below, including the cleanliness function values partly defining the transmission values. Relativities between the different sub-performances occur in the matrix, as for transmission and cleanliness. Some cells are left blanks, as the relativities demand further iterations for giving a reliable result. The design requirements and preferences are derived from the performance objectives.

The principal drivers as the highest hierarchical level in the design model generate the framework for the design by defining and dimensioning the geometric units and performance objectives. The output of the principal drivers becomes as input parameters that define following the intermediate construction, from where the geometry is a reflection of. The resulting geometry is thus the consequence of the construction, management and input of the intermediate construction.

The performance objectives and design requirements and preferences are all defined as cost functions from 0 to 1. The higher the cost function the better performance in terms of the objective related to the design requirements and preferences.

TABLE IX
RESULTS FOR IMPROVING HOSPITAL PROCEDURES

		Clinical specializations of thorax, circulation, hormone and musculoskeletal					Improving Hospital Procedures							
x_i	i	Type	Numb	Area	Length	Width	Cleanliness	Transmission	Noise	Privacy	Daylight	View	Orientation	Proportions
i={1,2	i in R_n						$P(A)$	$P(B)$	$P(C)$	$P(D)$	$P(E)$	$P(F)$	$P(G)$	$P(H)$
-	-	A	50	35	5,2	6,7	0,375	-	-	-	1	1	-	-
1	-	D	1	28	4,6	6,1	0,375	-	-	-	1	0	-	-
2	-	B	4	30	4,8	6,3	0,375	-	-	-	1	0	-	-
1	-	C	1	50	6,2	8,1	0,375	-	-	-	1	0	-	-
-	-	A	29	35	5,2	6,7	0,375	-	-	-	1	1	-	-
2	-	D	2	27	4,5	6,0	0,375	-	-	-	1	0	-	-
1	-	B	10	30	4,8	6,3	0,375	-	-	-	1	0	-	-
2	-	C	2	50	6,2	8,1	0,375	-	-	-	1	0	-	-
-	-	A	3	35	5,2	6,7	0,375	-	-	-	1	1	-	-
1	-	D	1	21	4	5,3	0,375	-	-	-	1	0	-	-
2	-	B	5	30	4,8	6,3	0,375	-	-	-	1	0	-	-
1	-	C	1	50	6,2	8,1	0,375	-	-	-	1	0	-	-
2	-	D	1	30	4,8	6,3	0,375	-	-	-	1	0	-	-
1	-	B	4	30	4,8	6,3	0,375	-	-	-	1	0	-	-
2	-	C	1	50	6,2	8,1	0,375	-	-	-	1	0	-	-
-	-	A	32	35	5,2	6,7	0,375	-	-	-	1	1	-	-
2	-	D	1	19	3,8	5,0	0,375	-	-	-	1	0	-	-
1	-	B	2	30	4,8	6,3	0,375	-	-	-	1	0	-	-
2	-	C	1	50	6,2	8,1	0,375	-	-	-	1	0	-	-
-	-	A	42	35	5,2	6,7	0,375	-	-	-	1	1	-	-
1	-	D	3	30	4,8	6,3	0,375	-	-	-	1	0	-	-
2	-	B	15	30	4,8	6,3	0,375	-	-	-	1	0	-	-
1	-	C	4	50	6,2	8,1	0,375	-	-	-	1	0	-	-
1	-	B	1	30	4,8	6,3	0,375	-	-	-	1	0	-	-
1	-	E		1.919	38	50,5	0,25	-	-	-	1	0,5	-	-
-	-	F		140	10,3	13,6	0,0625	-	-	-	1	0,75	-	-
2	-	G		532	20	26,6	0,25	-	-	-	1	0,5	-	-
2	-	H		147	10,5	14,0	0	-	-	-	0	0	-	-
-	-	I		154	10,8	14,3	0,25	-	-	-	1	0,25	-	-
-	-	J		59	6,7	8,8	0,25	-	-	-	1	0,25	-	-

IV. CONCLUSIONS

In the parametric process, it is ultimately the architect's responsibility to have an overview of the process, in terms of the design intentions and needs. By a responsible process the architect is able to make well-argumented choices, where the factors to parameterize and the weight to each other are defined through the process, and the factors and methods in use are strategized [33]. Managing the complex system of a parametric model requires understanding for the complexity and flexibility of the model, which also is illustrated through the examples in the present paper, where the bindings between the several performance objectives must be understood, and the overview maintained in the complex relationships.

By emphasizing performance and processes over appearance and representation it encourages integrated design and consists of a more empathetically collaboration with progressive structural engineers and other constructional discourses along with functional performances in the architectural process. Architecture folds itself into the other disciplines that define the building industry [32].

Today's hospitals have several logistic and organizational problems, because the logistics have not been included initially in the broadest possibly understanding. The complexity of the building typology necessities focuses on functionalities and bonds to achieve highly functional hospitals, and by the presented design model the complexity of the hospital drives the design along with the bindings interrelating to the functionalities. This facilitates well-performing hospitals designed by a functional performance-based model.

Parametric design is one architectural development derived of the computational capacity, where the use of a parametric construction and a bottom up approach is utilized. Generating form through computational capacity or creativity is a subject that has been debated for several decades. A common argument in the discussion is that computational architecture has a detrimental effect on the intrinsic tectonic nature of architecture, and that architecture essentially arises out of the tectonic capacities of actual materials [34]. However, it is worthwhile to consider tectonics in the context of digital media. The essence of tectonics can be described in terms of the tools, knowledge and techniques available at a certain time. Digital technology is exemplified in the generative tools currently employed in architecture. As architecture throughout history has developed coincidently with the tools available to it, computational architecture may be seen as a natural successor in the architectural tradition; hence digital techniques can be considered in terms of their tectonic potential. This paper approves this argument.

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