"INTERDISCIPLINARY ANALYSIS OF SIGN SYSTEMS AND GUIDANCE SYSTEMS IN HOSPITALS"*

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Introduction

Viscosity for liquids relates shear stress and the velocity profile of a fluid under that stress. Such concept has been applied also to gases.

In Physics, the concept of viscosity is used in several situations and its initial definition has been changed and adapted to several circumstances. In this article we shall apply such concept of viscosity to fluxes of people inside a building structure.

The use of physics parameters to quantify the quality of fluxes in different built structures will allow us to predict or experiment the efficiency of changes in the sign guidance system.

Using the Principle of Dimensional Homogeneity in physics we developed a formula, using the parameters measured, concerning the quality flux of people, to compute a valid value of viscosity for each origin-goal section inside the building.

In a query made in destination points in different hospitals, we inquired on several questions in order to obtain data to characterize the orientation system. We also inquired about the relations between anxiety and visual interpretation.

We were able to observe the relation between the increase of anxiety and pictogram/written information efficiency.

In the same way we were able to identify differences between a clustered organized building and a symmetric one using the proposed methodology.

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1. The Hospitals

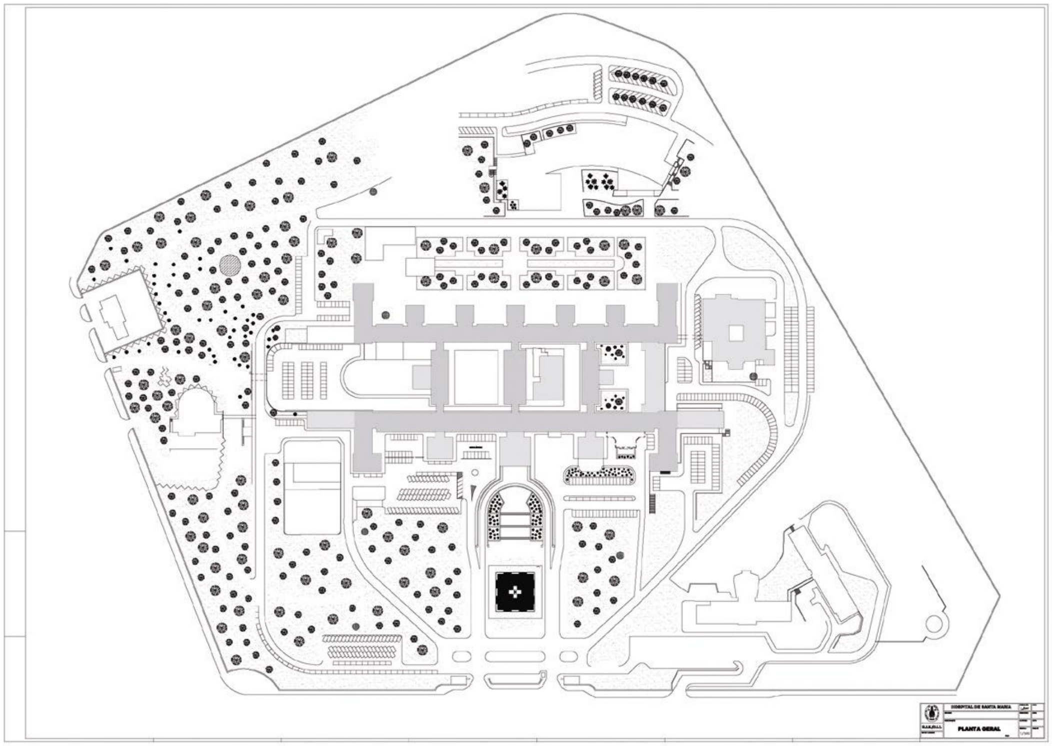

Figure 1. Hospital de Santa Maria, Lisbon, a large health care facility of German Design, is a University Hospital built in the 1950s.

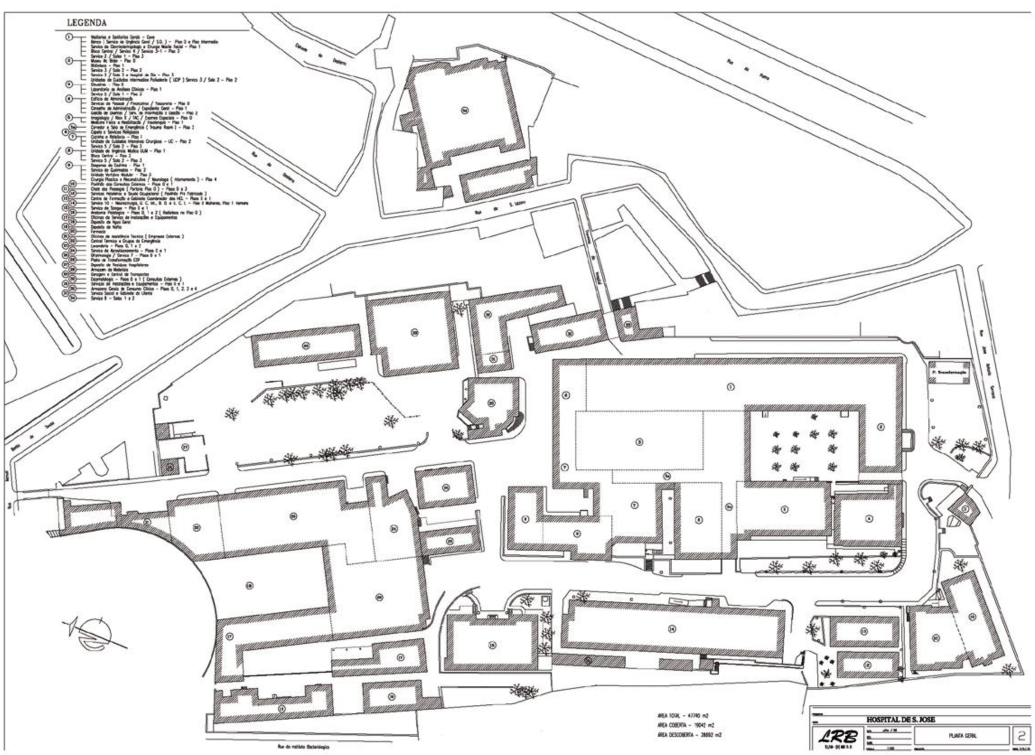

Figure 2. Hospital de S. José, Lisbon, a former Catholic Convent is also linked to a University, adapted since the 1830's.

Although we have tried a newly built hospital in Lisbon (CUF-Descobertas), it wasn't possible due to the refusal of its private board of administrators.

We will conduct the query for a recent building in Hospital da Cova Beira in Covilhã. Such structure is also a University Hospital.

These three structures represent, each, a specific kind of building used for these facilities in Portugal. The symmetric building, Santa Maria, the cluster organization, S. José and finally the new building structure used in the last decade.

2. The Query

We have divided the query in seven groups.
The first group analyses the previous experience of each agent before the present visit to the hospital. Such experience can consist, for example, in previous visits to the hospital.

The second group is an established and certified method to measure anxiety.

The third group intent to measure the difficulty and mistakes while walking a path "A to B".
That must be made at B after the path is completed.

The next group studies the orientation methods used by people.

The group five studies the impact and use of the sign system.

The last two groups analyse the capacity to interpret visual and written information and willingness to read and interpret the signs in a limited time interval.

3. The Architectonical Relativistic Viscosity Parameters

The definition of viscosity is made by the use of the equation below:

$$F/A = \eta . v_0/d \qquad \text{(1) – Absolute viscosity}$$

In the metric system absolute viscosity has units of kg / (m*sec). In order to obtain the equation for the viscosity in a building structure the principle of homogeneity can be used.

First, the variables of which viscosity is a function must be identified:
Suppose a certain corridor from two places, A and B, in a general architectonical space. The flux of people, agents, crossing that corridor characterizes its viscosity. That is, the easiest is the flux the smaller is viscosity.

Notice that, as we shall see, the average velocity will be a function of the number of times an agent stops to gather information about directions using several methods, in order to reach a certain goal.

Therefore, the flux of people can, in first approach, be considered like a fluid, where the "particles" are actually connected by information exchange necessity.

Connections between "particles of the fluid" are established, for example, when a person stops to ask another for directions.

Friction with walls here not considered will be related with the necessity of observing the architectonical space. The least knowledge about the space demands much more stopping time in observing signs on the surrounding space.

Due to queries characteristics we are unable to determined the exact path used by an agent when walking from A to B. Therefore, the results observed in the query for a certain origin-goal section from A to B are regardless of all possible paths to reach B from A.

We considered only the ideal path (the one of least distance) and all others are errors decreasing the average agent velocity.

The viscosity parameter, η, therefore, characterizes the building structure and is not a way to choose between two possible paths from A to B.

4. Relativistic Width of a corridor as a function of Space Syntax Concepts

If we think in terms of the width of the corridor we immediately realise that, as we decrease d, we increase viscosity, since the components travelling there will have a higher chance of colliding, that is, the flux decreases.

Yet, such is not a realistic view of an architectonical space. The widths of corridors are not limits, except in emergency situations or jams, to the agents' movement.

Nevertheless, it is possible to define a "relativistic width" (d_{rel}) dependent of the real spatial parameters that limit fluxes.

Such quantity shall be computed using spatial syntax analyses. We shall define that the relativistic width is a direct function of the "integration" of the line, after the space syntax analyses of a certain space is made. In short, more integrated lines are wider than less integrated lines.

In order to have a normalised quantity for different buildings we shall divide the line integration by the maximum integration value present in the architectonical space:

$d_{rel} = d_{rel}$ (line integration/maximum line integration value) (2) – Relativistic width

We can establish that:

d_{rel} = (line integration)/(maximum line integration value) (3) – Relativistic width

We can, therefore, see that one of the variables of which the viscosity depends upon is the width of the corridor, d.

$$\eta_{rel} = \eta_{rel}(d_{rel}) \quad \text{(4a) – Width d as a parameter}$$

For a A to B section we use the average integration value of the lines present in the ideal path divided for the maximum integration value in the system.

5. Agents “Mass” as a function of Agents Error probability. The relativistic characteristic of viscosity.

We are thinking in terms of agents, in this case, people. If we think of people walking in a building we would not, except if they were running, state that the most important factor for its speed is its weight.

The importance of the actual racing speed would be an important factor studying emergency building evacuations, which is not the case here.

In our study, and using practical observations *[annex reference]* we have come to the conclusion that it’s the knowledge and psychological characteristics that determines its capacity of information interpretation, which we associate with its “mass”.

That is, mass will be measured by the stated error probability of a certain agent in finding its correct root inside a building structure.

It will, therefore, be a “relativistic” mass in the sense that the only factor observed, the error probability, is chosen by us, observers, as the important factor to measure the agent’s mass.

$$\eta_{rel} = \eta_{rel}(m_{rel}, d_{rel}) \quad \text{(4b) – Variables of the relativistic viscosity function}$$

Where m_{rel} is defined by:

$$m_{rel} = m_{rel}(\text{Error probability}) \quad \text{(5) – Relativistic mass as a function of error probability}$$

If we think in terms of viscosity we realised that this is an important parameter for computing viscosity since takes in account the properties of the “fluid” we are considering.

The error probability of the agents and, therefore, its “mass” increases with lack of capability to interpret both visual and written information. Such factor shall be considered when computing the agents’ mass.

In practical terms, the mass will, therefore, be computed using a query independent of the surrounding architectonical space. The data to compute mass are obtained from the last two groups of the query (groups 6 and 7 of the query).

$$m_{rel}, = m_{rel}(\text{visual and written interpretation}) \quad \text{(6) – Relativistic mass}$$

In practical terms, in order to obtain a value for an agent “mass” we shall use the relation:

$$m_{rel}, = \langle \text{visual errors} \rangle + \langle \text{written errors} \rangle \quad (7)$$

To avoid null mass we add one:

m_{rel}, = <visual errors> + <written errors> + 1 (8)

To have the mass measured in quilograms we multiply all by 1kg

m_{rel}, = [<visual errors> + <written errors> + 1] . (1kg) (9)

6. The average Velocity as a function of Space properties.

The agents' properties have been characterized by its relativistic mass. But space inside a building has inner properties that must be taken in account. Namely, in a large building, signalisation, architecture and other factors will determine the flux velocity.

Therefore, one parameter, capable of measuring these architecture characteristics is the "average velocity" of the agents. The data to compute velocity are obtained from the third group of the query (questions 8, 9 and 10) related to the average velocity measured in the field crossing the shortest path with ;

The average relativistic speed of an agent will be computed by:

$$V^{rel} = V_{max} - n^*(V_{decrease}) \qquad \text{(10) – Relativistic Velocity of agents}$$

Both V_{max} and $V_{decrease}$ can be experimentally determined by field queries.

Actually, in practical terms, people will consider a stop every time they stop, whatever the reason for stopping, thus this is a good measure for their average speed. To compute $V_{decrease}$, we count all the stops due to using wrong routs, requiring others help for orientation and observing surrounding architectonical space for orientation.

Notice that this direct relation with stoppage time and velocity could not be so simple if the path size would tend to infinite. In such case only a formula relating total time and stoppage time would be possible.

Also, the stoppage time is an average time. Situations like someone deciding to camp in the middle of corridor could not be taken in account!

Acceleration is also not important to consider since the values for the velocities are small enough quantities that makes acceleration almost instantaneous. For us, the agent, either moves with a constant speed or is stopped.

We can, therefore, consider, average velocity, as an important factor for computing relativistic viscosity:

$$\eta_{rel} = \eta_{rel} (m_{rel}, v_{rel}, d_{rel}) \qquad \text{(4c) – The average speed as a parameter}$$

7. A Formula for measuring the Architectonical Relativistic Viscosity using the Principle of Homogeneity of Equations in Physics

From previous experiences [1][2][3], it is known that:

$$F/A = \eta . v_0/d$$

From this expression we verify that, in the metric system, absolute viscosity has units of kg / (m*sec):

$$[\eta] = Kg.m^3.s^{-1} \qquad (11) – \text{Units of } \eta$$

Therefore, any expression to determine η must have these units as a result.
We have already identify the variables of which η_{rel} depends upon, so we can write:

$$\eta_{rel} = \eta_{rel} (m_{rel}, v_{rel}, d_{rel}) \qquad (12) – \text{Variables of the relativistic viscosity function}$$

According to the analyses made, it is now possible to write a general expression for η_{rel} that, applying the Principle of Homogeneity of Equations in Physics will allow the determination of the dependency of η_{rel} relatively to all the variables of which it depends on.

Knowing the dimensions of each one of the variables it is possible to determine the explicit dependency of η_{rel} relatively to each one of the variables.

$$\eta_{rel} = v_{rel}.\ m_{rel} / d_{rel}^{\ 2} \qquad (13) – \text{Relativistic viscosity Equation simplified}$$

This formula allows the computation of viscosity of any corridor of constant width d, for a person of relative mass m_{rel}, travelling at an average speed v_o
.
If more than one person is walking trough the corridor the viscosity must take it in account.

It can do so by computing the average for all terms for example:

$$\eta_{rel} = \langle v_{rel}\rangle.\langle m_{rel}\rangle / d_{rel}^{\ 2} \qquad (14) – \text{Average Relativistic Viscosity Equation}$$

Where $\langle m_{rel}\rangle$ is the average relativistic mass of all people and $\langle v_{rel}\rangle$ is the average speed of such persons.

8. Proposals for Path Choice Optimisation

Distance is, as we have seen, the only parameter, in the described conditions, that actually matters to optimise the effort of reaching a location inside a building structure.

Therefore, if one thinks of creating a signalisation system to optimise traffic it must have, as goal, taking in account all error factors previously described, diminish the average distance to reach from any point to any other point in the building using the shortest path possible.

This conclusion does not imply that all intersections must have a sign indicating all possible locations. Such would create a major confusion, at least.

An optimal state of signalisation placing and spatial location must be determined.

In a first analyses it seems, from the observed above, that signs must reduce viscosity and approximate the paths chosen using the viscosity concept, to those chosen using the least action principle.

It is now possible to compare action and viscosity values to check if the least action path is also the one of least viscosity.

Conclusions

The queries, although depending of the quantity of people interviewed, already allow a characterization of the flux inside hospitals structures. The characterization of speed and mass can be more developed and accurate once accepted the principle of what kind of information can be included and computed. For different built structures we must respect the same principles. Also the inquiries must be performed in the same way after introducing information in the systems. “Luckily” one of the Hospitals (Santa Maria) almost doesn’t have signalisation!

Viscosity, since relates agents difficulties with integration is a correct measure of fluxes distribution inside the buildings before and after the alteration made in the sign system.
At this point we have concluded that the average velocity (V^{rel}) is higher in S. José for similar values of mass in both hospitals. It doesn’t depend on “hospital culture” since, on average, people in Santa Maria went there more often.

It was also possible to verify that anxiety is a crucial factor of sign reading capability. It clearly shows that written and visual information must be combined to improve, for all levels of anxiety, efficiency.

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