Education

Impact of the centrality for public spaces - a case of railway station

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Abstract

Navigation is a process of ascertaining one's position, planning and following a route. Navigation plays a crucial role in interactions and functions within the building design. While finding the way, knowing the person's location and the point to be reached is a fundamental activity in our daily life. This strategy is a little more complex in public indoor environments as the buildings have different floor plans, branching out corridors, functional spaces of varying magnitude and with horizontal/ vertical movements. A primary survey was conducted to track the passenger's navigation patterns during peak and non-peak conditions. Video cameras were installed at important locations to obtain mental maps for assessing the navigation pattern followed by the passengers within the indoor lobby space. The closeness-centrality analysis has been conducted to analyse the intuitiveness of the indoor circulation pattern flows of the passengers by the identification of passenger congregation spots (P-Cells) and Trajectory spots (T-Cells). Since the "correlation coefficient R= 0.76 and P-Value is 0.000374" (As obtained from the analysis of the empirical data), The result is significant at $p < .05$. we have found a strong positive correlation, that the closeness centrality values of the trajectory spots have significantly influenced the congregation spots (P-Cells) within the vicinity of the higher attractiveness criterion of the functional area. The research is also extended to examine the influence of central access lines (X and Y) on the P-Cells and T-Cells of passengers while navigating within the indoor space. These findings could conclude a design decision towards the centrality of indoor space, with reference elements like landmark realisations and functional object arrangements in a more emotive and user-centric manner. The conclusions of this research would help to draw the navigation models for better strategies like wayfinding, landmarks, object placements, rerouting of movements, and significance of activities, architectural behaviour with objects, de conjunction the navigating passage and visual referencing within the indoor built environments.

Keywords: indoor navigation, cognitive spaces, mental maps, place nodes, trajectory nodes

1. Introduction

It has been observed that most people often face problems to find their directions within public buildings like airports, railway transit stations, medical environments, universities and others since there is no proper indoor navigation supporting architectural design aids. This paper aims to understand objects of influence/ attractiveness on a commuter having certain predetermined perceptions about the space while navigation in a functionally known space anticipating commuters' expectation to fulfil the purpose of navigation. The designed objects and their locational significance have to support the commuters' anticipation and facilitate to ease of the process of navigation for wayfinding through architectural design. Present outdoor navigation directing systems are using technologies that extensively offer user-friendly and easily help people to find their way. However, indoor built environments are further complex by the way of building patterns, and their orientation is complicated by their scale and smaller spaces in and around them. Besides, people have the choice to navigate freely within the rooms or corridors or concourses in contrast to the network of outside roads and streets defined by the stipulated rules and guidelines. But indoor navigation, the systems of people's flow and their choices of segregations and aggregations should be considered. "Additionally, in indoor environments furniture, columns, podiums and groups of people might act as obstacles thus they need to be considered while orienting and navigating" ("Nagel et al., 2010") [11]. "As the rise of indoor activities nowadays, and the difficulty of indoor environments demanding contextually-aware indoor navigation systems to govern the most ideal route from one location to the other" ("Afyouni, Ray and Claramunt, 2012; Becker, Nagel and Kolbe, 2009") [1, 2]. The focus of this research is on the intuitiveness of passengers' navigation in a railway station entrance and ticketing lobby. The Key component of this research is to analyse how passengers take decisions while navigating towards their functional activities, and the level of services that align with the layout of the indoor environment. "It has been observed that various models developed to pave the way to decision-making strategies which have been analysed" ("Crompton, 1992; Gursoy & McCleary, 2004; Huan & Beaman, 2003; and Sirakaya, McLellan, & Uysal, 1996"), by a few qualitative and quantitative research studies, have endeavoured to evaluate the data empirically.

The case study has been conducted in the Vijayawada railway station with the consideration of its passenger footfall at each entrance and exit point. Predominantly, the main entrance lobby has services such as ticket counters, seating places, display areas and so on.

2. Problem identification

"The connections amongst the 'people', 'space', and 'time' are the key attributes for all functions. However, navigation is an 'event' of a person which plays a crucial role in how the building functions" "author, (2022)". The indoor environments

are having more complexity due to the building's layout organization and its vicinities among the functions, which is a great challenge due to its multiple events. The task of movements is associated with the place criterion and action criterion, through locating the system which influences the capability, perpetually recognizable, barriers and cushioned spaces. The 12 wireless CCTV have been installed at different locations to capture passengers' movement/navigation. The total number of passengers Navigation, direction, navigating territorial area of occupancy and time spent on direction, changing nodes, and overall duration of time at different trajectories have been marked and analysed.

The author conducted a survey to understand the passenger's selection of the entry/exit points on 9 Oct 2020, 17 Nov 2020, 3 Feb 2021, 5 Jan 21, 6 March 2021, 23 July 2021, and 10 Dec 2021 at different times of the day. The total passenger movement survey averaged 96248, against all exit/entry points; the main entrance towards the 2-Town side has maximum passengers movement of 29130 persons (49%), so the ticketing cum lobby area of this space has been considered for the assessment and appreciation of Intuitive Navigation of the passengers. The author has conducted a survey to track the passenger's navigation during peak and non-peak conditions. Video cameras were installed at important locations to extract the mental maps for collecting the data, and to assess the navigation pattern behaved by the passengers within the indoor lobby space as mentioned.

3. Empirical study on the entrance lobby of the railway station, Vijayawada

The study on activities concerning the access lines of the indoor lobby space has been coded with reference to the activities in the "Ticketing cum Lobby "space such as ticket counters, ticketing vending machines, railway enquiry counter, souvenir shops, food court, display space for arrival and departure schedules etc., as shown coding and locational in the table 1 and in Fig.1.respectively. The unique numbering of activities and their affiliations with the functional objects and how it influences passenger navigation within the lobby space has been illustrated and analysed further.

Table 1: Coding of Objectives

Code	Objects / activity	
1	Tourist Counter	A1
2	Tourist Counter	A2
3	Religious Space	B1
4	Painting, Art forms	C1
5	Central Space	D1
6	Central Space	D2
7	Painting, Art forms	E1
8	Booking Counter/Inquiry	F1
9	Seating Spaces	G1
10	Seating Spaces	G2
11	Entry	H1
12	Entry	H2
13	Entry	H3
14	Information Screen	I1
15	e-ticket vending machine	J1
16	e-ticket vending machine	J2
17	e-ticket vending machine	J3
18	e-ticket vending machine	J4
19	e-ticket vending machine	J5
20	e-ticket vending machine	J6
21	e-ticket vending machine	J7
22	e-ticket vending machine	J8
23	e-ticket vending machine	J9
24	Food track	K1
25	Display Zone	L1
26	Postal Unit	M1

The various activity-related spaces have been marked with respect to the distances from the defined access of movement from all three entry points to the exit point to platforms as shown in Fig.1. The monochromatic shade of the heat map indicates a darker shade of green is closure to the central access lines.

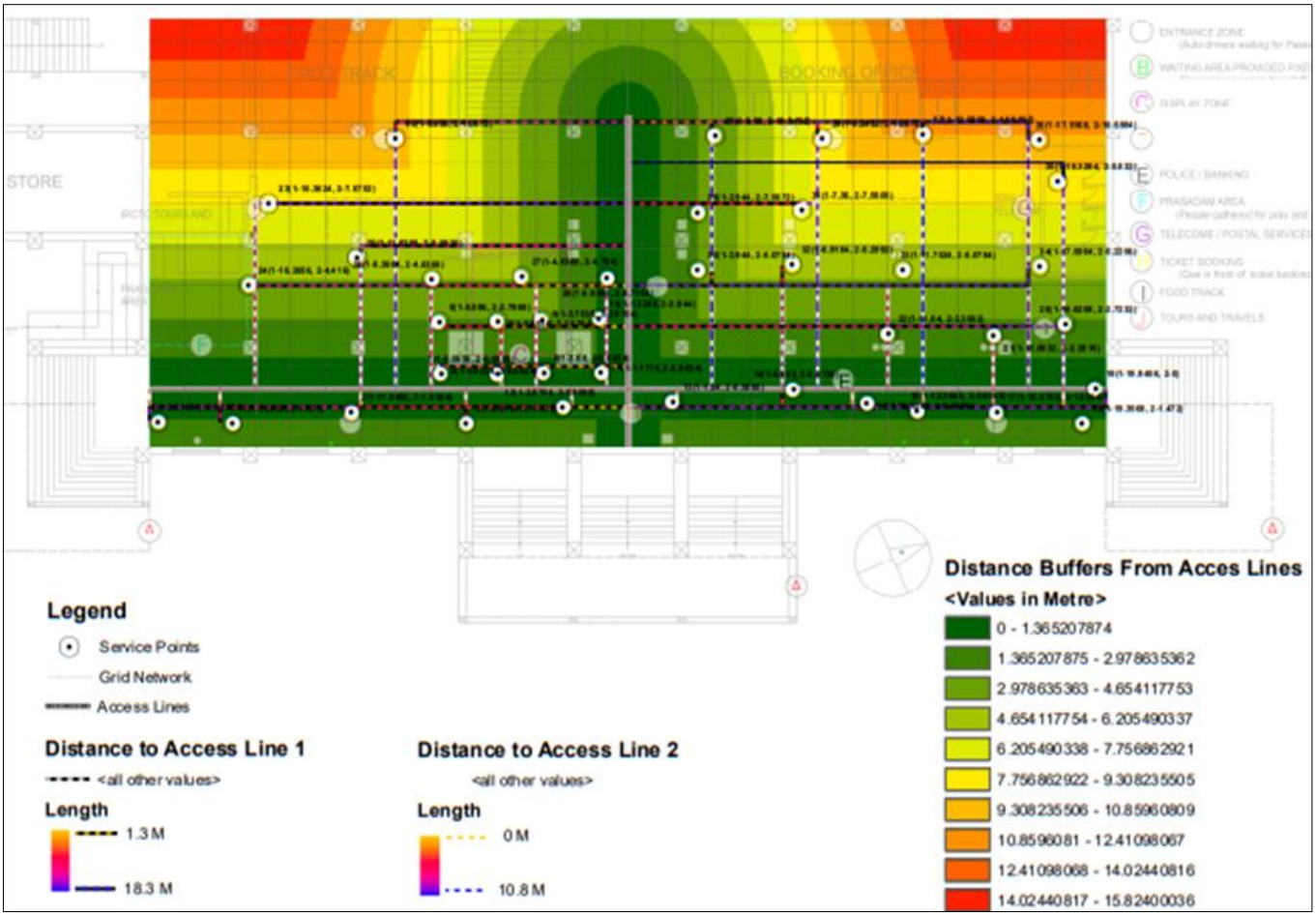

Fig 1: Delineations of distances among the functional object systems within the Lobby space

Access line one has considered a southern entry to a northern entry shown as 1, whereas access line two has been considered as an eastern entry to a western exit shown as 2, similarly access lines three and four have considered northern and western entry/exit as shown 3 and 4.

4. Illustration of mental maps

The captured data of passengers' navigation along with the data of functional areas, and navigated time with their baggage areas has been extracted and mapped. Besides the data sets have been analysed to draw findings and inferences. Further, it has worked on the overlapping / extrapolating of samples of their mental maps shown in Figure 2 to verify the patterns and plotted the deflection points of navigation designating as T-Cells in Figure 3, and congregation point spots designated as P-Cells plotted in Figure 4 emphasising the movements made by the passengers.

These illustrations helped to understand the passenger's behavioural navigation which has been influenced by the indoor layouts and service positioning systems. Fig. 2 shows the navigation of passengers from three different entries in three different shades to the 'Lobby Cum Ticketing Space' [LCTS], the southern side entry has shown 55% of passengers' movement shown in purple, the eastern side shows 41% in blue shade and northern side shown only 4 % in the green. The entry footfall-related percentage is only due to the city-side parking layout and access of pedestrian movement as the external design consideration has got a strong influence on the density of passenger navigations in LCTS. It is also been captured the modulations in the speed of navigation due to T cells and P cells with specific reference to the attractiveness of activities within the visual cone. It is also observed that 25% of passengers focussed to identify the inquiry counter and then on ticketing, thereafter the display board for train schedules.

These passengers are probably unfamiliar with the premises, whereas 42% of the passengers' movement and their focus is on the overhead display board where their navigation speed comes to zero and then that area is used as a waiting space though the designated waiting area is closer to the northern entry.

It is been observed that such passengers are familiar in nature having reservation and just waiting for getting the updated information on display for the allotted platform of the train and 10.75% of the passengers appears to be daily commuters to suburban areas where their navigation is straight from entry to LCTS and exit to the platform. It is also observed 7.5% of passengers were in groups of three/ four members such as families having different age groups navigated by occupying maximum territorial space and moving from the entry to exit with the good quantum of luggage.

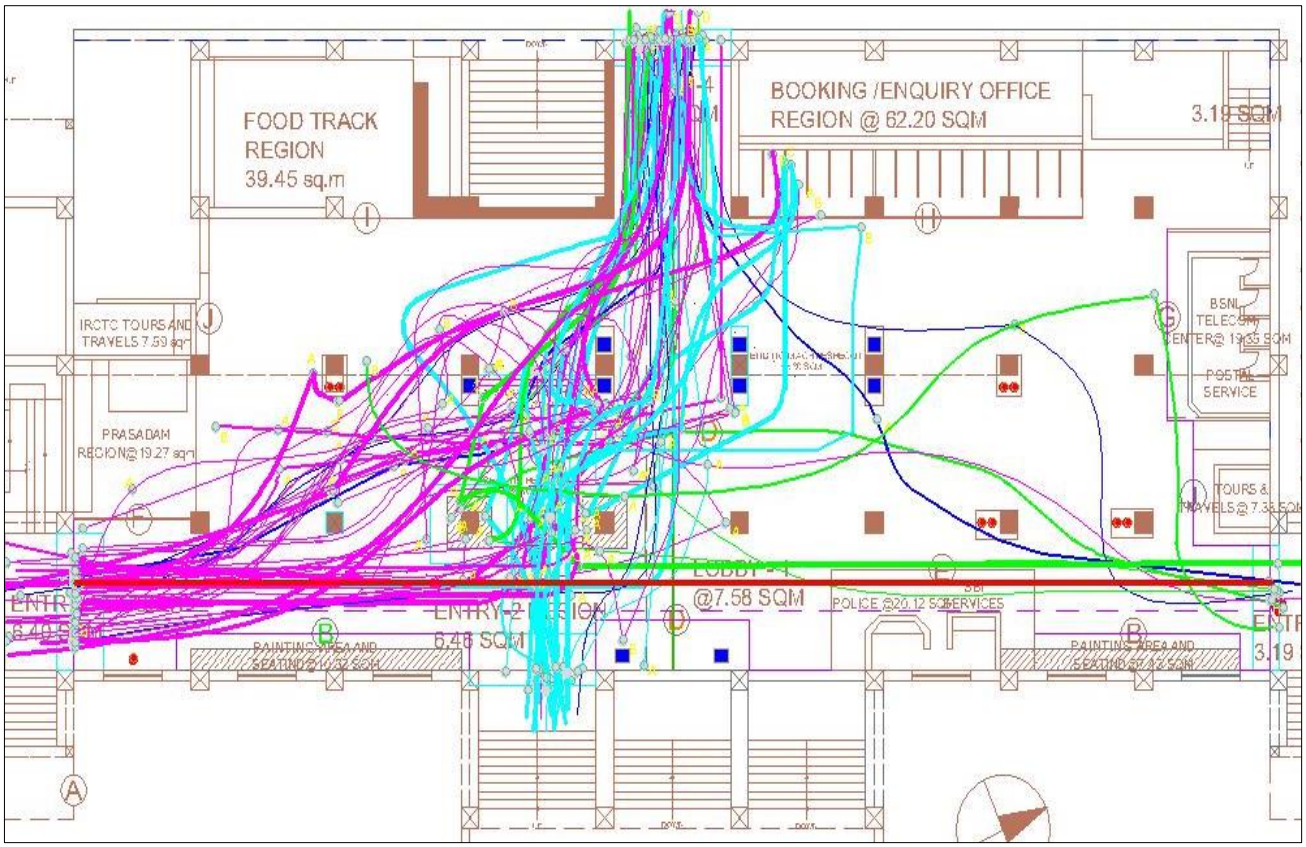

Fig 2: Plotting of Mental Maps of the Passengers

As per the objective of the research that it has been analysed that the entire lobby space has been subdivided with due navigation profile indicating the maximum significance is on the display area, ticket vending machines, ticketing and enquiry counter. The mental mapping at Fig.2 clearly indicates that core area with reference to its intensity and no intensity areas such as BSNL, postal service areas, 'IRCTS tours and travels' and food court areas. It clearly indicates that certain activities not having significance in lobby areas through fig.2, however, those activities are also essential and crucial to the overall functioning of the Railway station but it need not be a part of the lobby area.

The basic objective is to construct mental maps with an emphasis on T-cells showing the decision points with regard to the deflection points of passenger navigation. It can be seen in Fig.3 the intensity of deflection and decision points concentration at entry and exit points, besides at a place where the display of the trains scheduling screen.

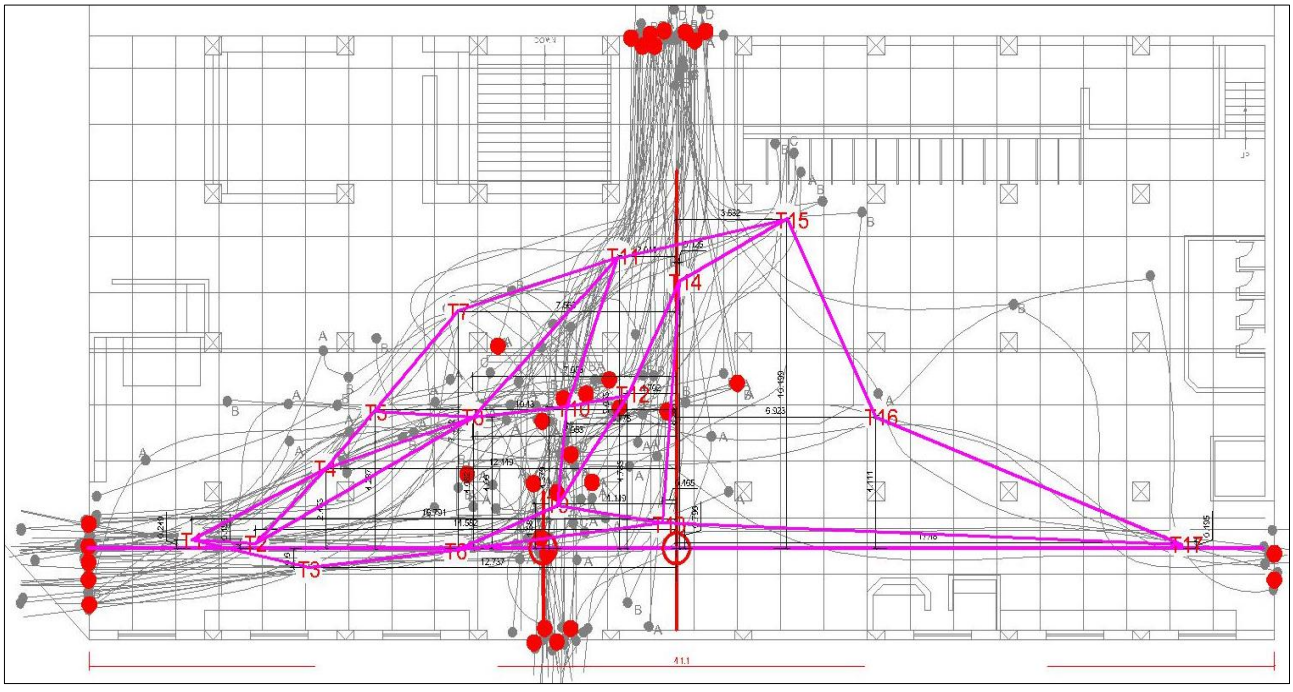

Fig 3: Plotting of T-Cells

The centrality of the movement can be identified in Fig.4 showing P- Cells at T9, T10 and T11. It is showing the interdependency factor among the variables of T- cells and P-cells. The navigation system operation can be seen with respect to the path direction from all entries to exits. The commuter activities with regard to the research objectives the variables interdependency, certainty and uncertain conditions have been analysed to understand the commuters' expectations in a LCTS.

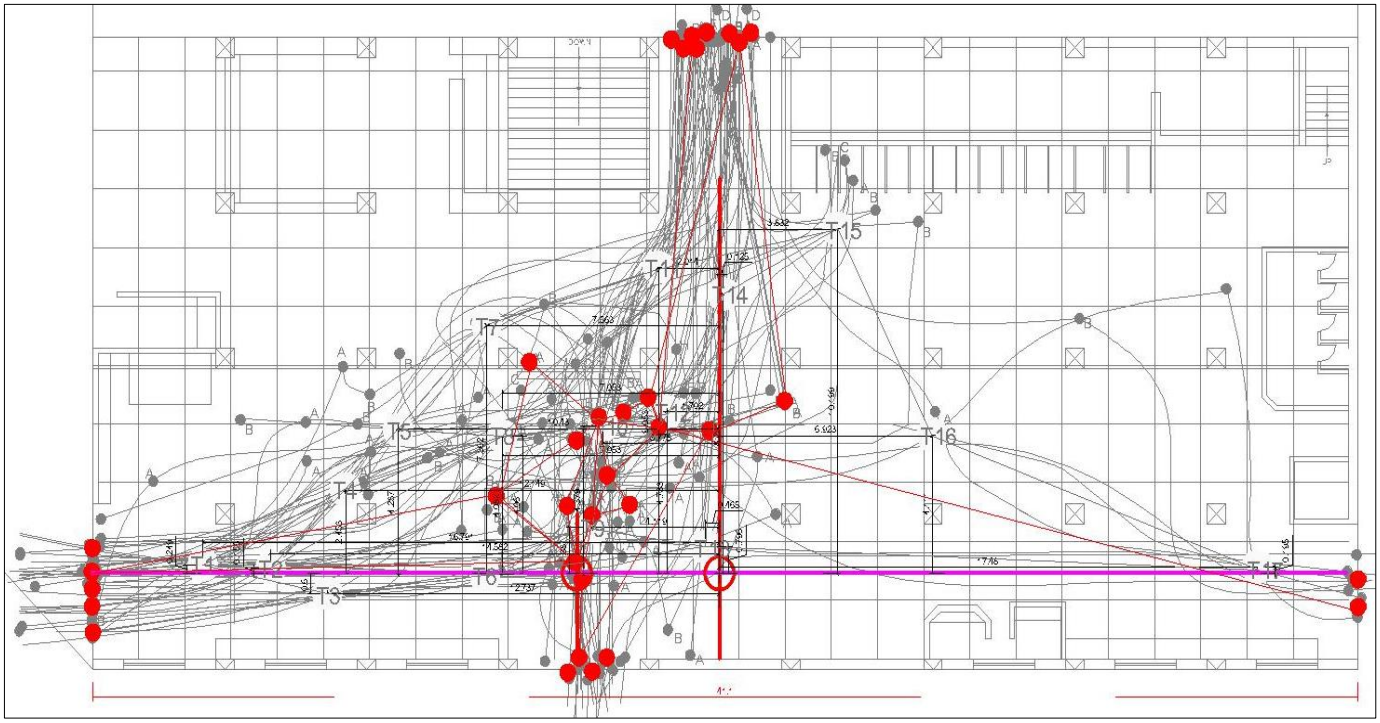

Fig 4: Plotting of P-Cells

The passengers behaviour certainly seen with reference to theirs navigation from all entries and its flow intensities with respect to the city side design interventions related to the parking of cars / autos / 2-weelars, movements of city buses and clock tower as a landmark bring the passengers and passengers entry from the town.

5. Impact of closeness centrality on the mental maps of passengers

Given indoor navigation, the following research question was framed to explore the decisions made by the passengers within the indoor lobby systems.

Research Question: How does the Closeness-centrality of T-Cells (Trajectory Cells) & P-Cells (Congregation Cells) impact the Passenger's mental maps while navigating from one point to another?

"Calculating centrality has been a major focus of social network analysis research for some time" (Freeman, 1977) [6]. "These measures are degree, betweenness, closeness, power, information, flow, and reach". Since current research is on indoor navigation, closeness centrality has been used to evaluate the centrality measures of empirical flow data.

"The node with the highest closeness centrality is the closest one to all other nodes and the closeness centrality of a node is the average length of the shortest path between the node and all other nodes" (author 2022).

$$C_c(i) = \frac{n-1}{\sum_{j=1}^{n}(d_{ij})} \qquad \text{------1}$$

Where, n= no of vertices and d_{ij}=distance between each node.

5.1 Closeness centrality of t-cells

Table 2: Closeness Centrality of T-Cells

0	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	sum	n-1	n-1/SUM
t1	0	2.202	4.104	5.118	7.541	9.239	11.813	10.465	13.011	13.732	17.482	16.011	16.451	20.052	23.34	30.197	34.459	235.283	16	0.07
t2	2.202	0	1.992	3.368	5.791	7.127	10.063	8.493	10.899	11.76	14.276	13.915	14.339	17.89	22.077	28.934	32.347	205.473	16	0.00
t3	4.104	1.992	0	5.36	7.783	5.135	12.055	10.485	8.907	11.979	16.923	14.134	12.347	18.109	22.296	29.153	30.355	211.117	16	0.08
t4	5.118	3.368	5-36	0	2.423	10.495	6.695	5.347	14.267	8.614	12.364	10.769	17.707	14.744	18.222	25.079	35.715	196.287	16	0.08
t5	7.541	5.791	7.783	2.423	0	12.918	4.272	3.447	10.189	6.714	10.055	8.869	13.883	12.844	15.913	22.77	31.891	177.303	16	0.09
t6	9.239	7.127	5.135	10.495	12.918	0	17.19	10.111	3.772	6.844	11.788	7.974	7.212	11.949	16.136	22.993	25.22	186.103	16	0.09
t7	11813	10.063	12.055	6.695	4.212	17.19	0	7.719	14.058	10.727	5.783	12.882	17.493	16.851	11.641	18.498	35.501	213.247	16	0.08
t8	10.465	8.493	10.485	5.347	3.447	10.111	7.719	0	6.339	3.267	7.017	5.422	10.033	9.397	13.584	20.441	28.041	159.608	16	0.10
t9	13.011	10.899	8.907	14.267	10.189	3.772	14.058	6.339	0	3.072	8.016	4.202	3.694	8.177	12.364	19.221	21.702	161.89	16	0.10
t10	13.732	11.76	11.979	8.614	6.714	6.844	10.727	3.267	3.072	0	4.944	2.155	6.766	6.13	10.317	17.174	24.774	148.969	16	0.11
t11	17.482	14.276	16.923	12.364	10.055	11.788	5.783	7.017	8.016	4.944	0	7.099	11.71	11.074	5.856	12.713	29.718	186.818	16	0.09
t12	16.077	13.915	14.134	10.769	8.869	8.999	12.882	5.422	4.202	2.155	7.099	0	7.896	3.975	8.162	15.019	25.904	165.479	16	0.10
t13	16.451	14.339	12.347	17.707	13.883	7.212	17.493	10.033	3.694	6.766	11.71	7.896	0	7.503	11.69	18.547	18.008	195.279	16	0.08
t14	20.052	17.89	18.109	14.744	12.844	12.974	16.857	9.397	8.177	6.13	11.074	3.975	7.503	0	4.187	11.044	22.291	197.248	16	0.08
t15	23.34	22.077	22.296	18.222	15.913	17.161	21.044	13.584	12.364	10.317	5.856	8.162	11.69	4.187	0	6.857	18.104	231.174	16	0.07
t16	30.197	28.934	29.153	25.079	22.77	24.018	27.901	20.441	19.221	17.174	12.713	15.019	18.547	11.044	6.857	0	11.247	320.315	16	0.05
t17	34.459	32.347	30.355	35.715	31.891	25.22	35.501	28.041	21.702	24.774	29.718	25.904	18.008	22.291	18.104	11.247	0	425.277	16	0.04

As illustrated in Table:2, the closeness centrality analysis has been conducted among T-Cells and the observations have been realised that T-10 has the highest closeness centrality value of 0.11“, as the average length of the shortest path between the T-10 and all other Trajectory Cells”, correspondingly, “T-17 has the lowest closeness centrality value of 0.04 as the average length of the shortest path between the T-17 and all other Trajectory Nodes”. It means the T-10 cell has the fact of being in a trajectory region and the most significant node, where the principal decisions were made by the passengers.

5.2 Closeness centrality of p-cells

As illustrated in Table:3, the closeness centrality analysis has been conducted among P-Cells and the observations have been realised that P-8 has the highest closeness centrality value of 0.16“, as the average length of the shortest path between the P-8 and all other Place Nodes, correspondingly, P-21 has the lowest closeness centrality value of 0.04 as the average length of the shortest path between the P-21 and all other Place Nodes”.

Table 3: Closeness Centrality of P-Cells

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	sum	n-1	n-1/SUM
P1	0	4.109	4.902	3.085	3.212	3.773	4.718	4.087	4.509	4.895	5.643	5.811	6.06	7.707	10.298	13.335	6.085	8.953	14.867	16.719	79.388	162.156	20	0.12
P2	4.109	0	5.61	3.791	7.3	7.63	5.702	2.789	4.529	3.597	5.663	4.513	4.762	6.409	9	15.517	9.942	9.937	10.758	15.421	26.09	165.069	20	0.12
P3	4.902	5.61	0	3.823	1.69	2.251	3.196	2.821	4.561	3.629	4.455	4.545	4.794	6.441	9.032	17.377	4.504	7.431	14.188	15.453	28.122	148.825	20	0.18
P4	3.085	3.791	3.623	0	5.513	4.631	2.703	1.002	1.424	1.81	2.558	2.726	2.975	4.622	7.213	16.42	6.943	6.938	12.369	13.634	26.303	130.483	20	0.13
P5	3.212	7.3	1.69	5.513	0	0.561	1.506	4.511	2.785	5.319	2.765	6.235	6.484	8.131	10.722	15.687	2.873	5.741	15.878	17.143	29.812	153.868	20	0.13
P6	3.773	7.63	2.251	4.631	0.561	0	1.928	4.947	3.207	5.755	3.187	6.671	6.92	8.567	11.158	16.739	2.312	6.163	16.314	17.579	30.248	160.041	20	0.12
P7	4.718	5.702	3.196	2.703	1.506	1.928	0	2.913	1.279	3.721	1.259	4.637	4.666	6.533	9.124	17.164	4.24	4.235	14.28	15.545	28.211	137.803	20	0.15
P8	4.087	2.789	2.821	1.002	4.511	4.947	2.913	0	1.74	0.1306	4.172	1.724	1.973	3.62	6.211	18.306	7.259	7.143	11.367	12.632	25.301	125.331	20	0.16
P9	4.509	4.529	4.561	1.121	2.785	3.207	1.279	1.74	0	2.518	1.13/	3.464	2.494	4.141	6.732	18.463	5.519	5.514	13.107	14.372	25.822	127.344	20	0.16
P10	4.895	3.597	3.629	1.81	5.319	5.755	3.721	0.808	2.548	0	3.809	0.916	2.781	4.428	7.019	19.114	8.067	7.965	12.175	11.824	26.109	136.28	20	0.15
P11	5.643	5.663	4.455	2.558	2.765	3.167	1.259	4.172	1.134	1.809	0	4.725	2.615	4.262	6.853	18.443	5.499	5.494	13.879	15.633	25.943	137.991	20	0.14
P12	5.811	4.513	4.545	2.726	6.235	6.671	4.637	1.724	3.464	0.916	4.725	0	3.697	5.344	7.935	19.146	8.983	8.872	13.091	10.908	27.025	150.968	20	0.13
P13	6.06	4.762	4.794	2.975	6.484	6.92	4.886	1.973	2.494	2.781	2.615	3.697	0	1.647	4.238	19.395	9.232	9.121	11.264	14.605	23.328	143.271	20	0.14
P14	7.707	6.409	6,441	4.622	8.131	8.567	6.533	3.62	4.141	4.428	4.262	5.344	1.647	0	2.591	21.042	10.879	10.768	12.911	16.252	22.19	168.465	20	0.12
P15	10.298	9	9.032	7.213	10.722	11.158	9.124	6.211	6.732	7.019	6.853	7.935	4.238	2.591	0	23.633	13.47	13.359	15.502	10.701	19.599	204.39	20	0010
P16	13.335	15.517	17.377	16.42	15.687	16.239	17.184	18.306	18.463	19.114	18.443	19.146	19.395	21.042	23.633	0	18.551	21.419	26,275	30.054	42.723	408.323	20	0.05
P17	6.085	9.942	4.504	6.943	2.873	2.312	4.24	7.259	5.519	8.067	5.499	8.983	9.232	10.879	13.47	18.551	0	8.475	18.626	19.691	37.56	203.91	20	0.10
P18	8.953	9.937	7.431	6.938	5.741	6.163	4.235	7.148	5.514	7.956	5.494	8.872	9.121	10.768	13.359	21.419	8.475	0	18315	19.78	32.449	218.269	20	0.09
P19	14.867	10.758	14.188	12.369	15.878	16.314	14.28	11.367	13.107	12.175	13.879	13.091	11.264	12.911	15.502	26.275	18.626	18.515	0	23.999	34.592	323.957	20	0.06
P20	16.719	15.421	15.453	13.634	17.143	17.579	15.545	12.632	14.372	11.824	15.633	10.908	14.605	16.252	10.701	30.054	19.891	19.78	23.999	0	30.3	342.445	20	0.06
P21	29.388	28.09	28122	26.303	29.812	30.248	28.214	25.301	25.822	26.109	25.943	27.025	23.328	22.19	19.599	42.723	32.56	32.449	34.592	30.3	0	568.118	20	0.04

It means, the P-8 cell is in an attractive region and is the most significant node where the principal congregations were made by the passengers.

6. Correlation between the 't-cells' and 'p-cells' while navigation within the indoor lobby systems

Correlation coefficients are used to degree of its association or relation is between two variables. There are several types of correlation coefficient, but the most standard is Pearson's. Pearson's correlation (also called Pearson's R) is a correlation coefficient commonly used in linear regression.

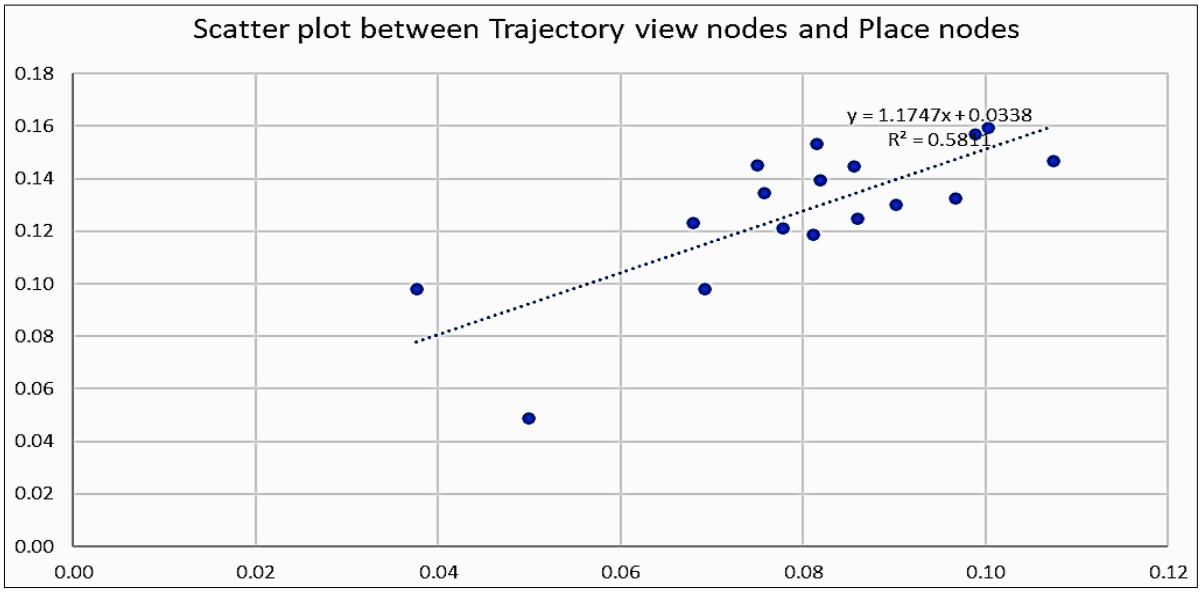

Fig 5: Correlational Scatter Plot among T-Cells and P-Cells

The correlation coefficient is a measure of the association between two variables of T-Cells and P-Cells. The formulas return a value between -1 and 1, where -1 shows negative correlation and +1 show a positive correlation. The correlation coefficient value is positive when it shows that there is a correlation between the two values and the negative value shows the amount of diversity among the two values, whereas T-Cells and P-Cells showing the positive correlation with the 0.58 valve of R^2 where R value is 0.763 as shown in the Fig.5

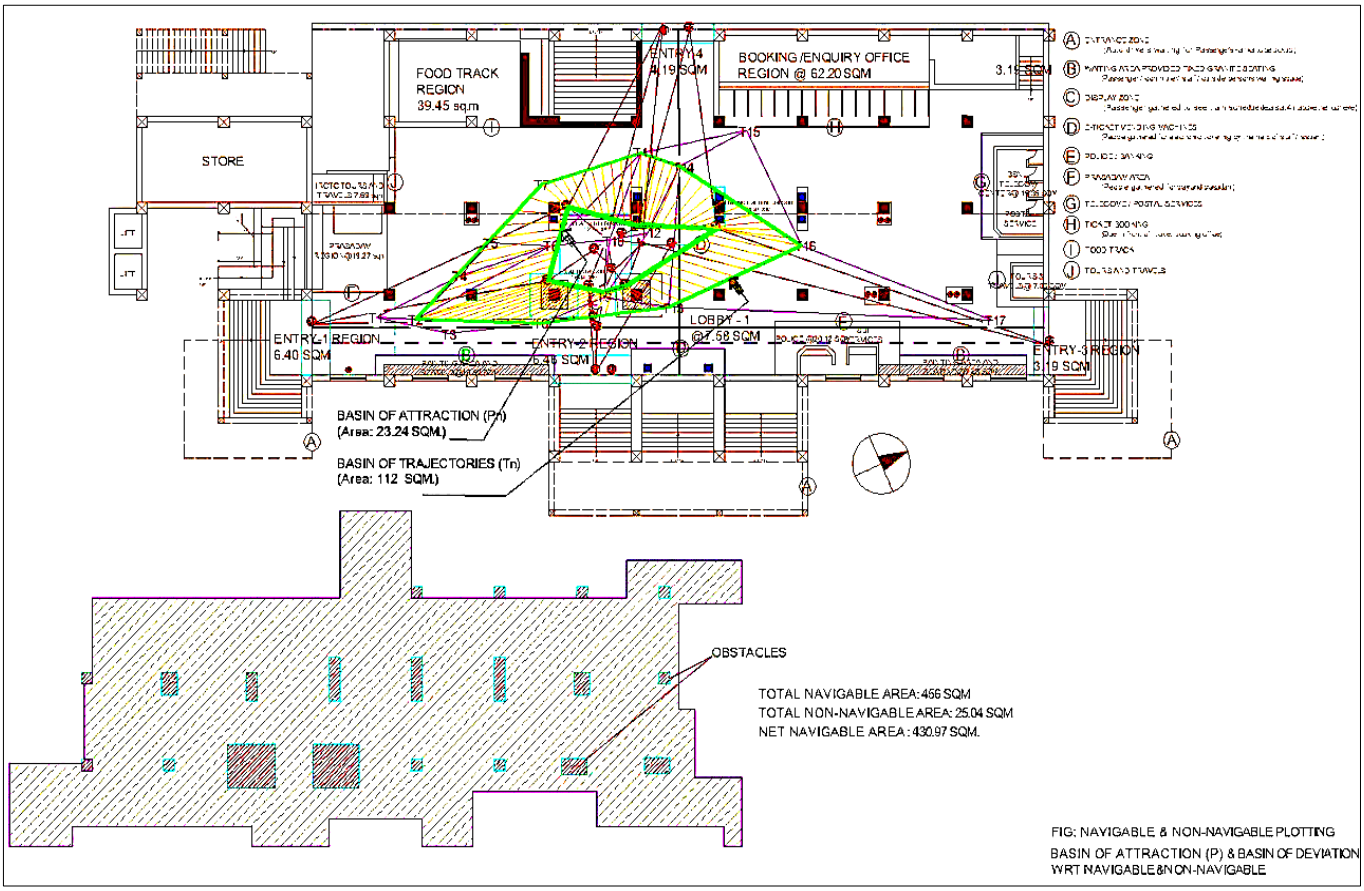

Fig 6: Region of Trajectory (Outer) and Region of Attractiveness (Inner)

The Study yielded an understanding of the positive correlation between the T-Cells and P-Cells. "The correlation coefficient R= 0.763 and P-Value is 0.000374" (as obtained from the correlation analysis), the result is significant at $p < .05$. It means the region of the Trajectory points (T-Cells) significantly and correspondingly made passengers move towards the most attractive object criterion (Train scheduled display board) and make them assemble within the P-Cells region for a while to obtain the essential functions. The regions of Attractive and trajectory cells were shown in Figure No.6.

7. Influence of central access lines (x and y) on passenger's deflection points and congregation points

In continuation to the correlation among the T-Cells and P-Cells, the research is extended to examine the influence of central access lines (X and Y) on the T-Cells and P-Cells of passengers, while navigating within the indoor space. The following 2 No's null hypotheses have been framed to prove the spatial relationships of the passengers while navigating.

Null Hypothesis-1: Passenger's Trajectory nodes (T-Cells) incurred during the navigation is depending on the alignment of 'X' & 'Y' access lines irrespective of functional object locations within the context of the Entry cum ticketing lobby of the Railway station as analysed and shown in Table 4.

Table 3: Relationship of Trajectory Cells and Central Access lines (X & Y)

T-Cells (Spatial Trajectory Cells) (Point of deflections incurred during Passenger's Navigation majorly)	Distance from Central Access lines	Distance from Central Access lines
	Y	X
T1	17.112	0.55
T2	14.9	0.456
T3	13.051	0.297
T4	12.428	2.784
T5	10.755	4.236
T6	7.951	0.254
T7	7.619	7.662
T8	4.358	7.112
T9	1.626	4.177
T10	4.679	3.845
T11	9.294	2.088
T12	5.033	1.72
T13	1.096	0.523
T14	8.563	0.05
T15	10.499	3.771
T16	4.372	6.864
T17	17.624	0.402

The location of T-Cells has been designated with respect to the Axis of north entry to south entry as X-Axis and east entry to west exit as Y-Axis. The distances have been calculated and the locational correlation among the T-Cells analysed. The study has proven that NOT having significance among the central access lines as per R-value - 0.445. Subsequently, the Trajectory Cells showed the P value as 0.07347 and further established the same insignificant level. The Majority of the Passenger's decisions regarding their deflection of pathways or head changing direction has not been depending on the alignment of 'X' & 'Y' central access lines of the indoor lobby space. It means, most of the passengers were taking decisions to deflect their movements significantly in the entry/exit regions while searching for attractive or necessary functional objects within the indoor systems. Hence the null hypothesis has been proven.

Null Hypothesis-2: Passenger's congregation nodes (P-Cells) acquired during the navigation is depending on the alignment of 'X' & 'Y' access lines irrespective of functional object locations within the context of the Entry cum ticketing lobby of the Railway station.

Table 4: Relationship of Place Cells and Central Access lines (X & Y)

Congregation/ Place-Cell (Point of congregations incurred meanwhile the Navigation majorly)	Distance from Central Access lines	Distance from Central Access lines
	Y	x
P1	7.194	2383
P2	6.055	6291
P3	4302	2.14
P4	4.579	4.067
P5	4.647	0A36
P6	4.453	0
P7	4.033	I978
P8	1859	4.688
P9	3269	3.009
P10	3.009	4234
P11	2267	2.124
P12	2217	5268
P13	I938	4373
P14	0284	4247
P15	2206	5.143
P16	20304	0
P17	4.481	2.446
P18	3362	2.446
P19	039	15.909
P20	031	15909
P21	20376	1081

Similarly, the correlation of place cells has been worked out and found that the R-value of -0.448 showed a negative correlation that led to a weak relationship. However, the study has shown that it has significance among the central access lines and Place Cells as the '*P*-value is 0.045 which is significant, where there is a probability of passenger congregations would depend upon both central access lines X' & 'Y', correspondingly within the vicinity of a higher attractive object criterion, which means within the region of the Landmark of the environment. Henceforth, it has been realised that most of the passengers were taking decisions to congregate themselves significantly in the intersecting location of X and Y access lines and also positioning within the proximity of attractive and landmark regions of the indoor spaces. Hence the null hypothesis has been proven.

8. Conclusions

With reference to the above study and analysis of Item Nos.5,6 and 7, the following research discussions have been realised.

1. The Study yielded an understanding of the positive correlation R= 0.76 and the P-Value is 0.000374 between the T-Cells and P-Cells. It means the region of the Trajectory nodes (T-Cells) significantly and correspondingly made passengers move towards the most attractive object criterion P-8. (Train scheduled display board) and make them assemble within the P-Cells region for a while to obtain essential services.
2. The study also yielded that Majority of the Passenger's decisions regarding their deflection of pathways have not been depending upon the alignment of 'X' & 'Y' central access lines of the indoor environment as the T-Cells have not shown significance (as P value is 0.07347.)
3. Similarly, the study against P-Cells found that positive significance P value of 0.045, the passenger congregations will depend upon both the central access lines 'X' & 'Y', correspondingly accumulating passengers within the vicinity of a higher attractive object criterion, which is within the region of the Landmark of the environment.
4. The pattern and the system of the indoor layout taken, predominantly drawing the passengers from multiple entry/ exit ways, and disbursing the same across a narrow passageway (bottleneck) towards the platforms or another enclosure of spaces, It was found that the design of the indoor spaces would depend upon the centrality of the indoor systems which promotes intuitive and perpetual navigation.
5. As stated in the above item 3 of the positive significance of P-Cells, the intersecting location of access lines and the proximity of landmarks would need to be considered for passenger waiting areas to obtain spatial information, and take decisions towards a strategy of a route to navigate to participate in further essential or desirable events.
6. The indoor spatial design needs to illustrate the user deflections and congregations across the landmarks, edges, barriers and functional object placements to yield the intensity of the space to make measures towards the optimisation viewpoints of the environment.
7. The results may pave the method to prove the degree of anticipation and perceptual levels of the passengers to determine the behavioural and user-centric parameters within the indoor spaces.
8. The food court at the southwest corner does have any significance in the mental maps generated with respect to the P-Cells and T-cells. There is no navigation to this side as it is not a requirement at LCTS.
9. Similarly, the passengers' behaviour at LTCS is quite different with respect to their intuition so the postal / carrier not significant as these Items can be located elsewhere.
10. The design of ticketing counters in a row parallel to the north-south orientation is not effective as only the counters nearer to the central axis have been realised / interactive.

References

1. Afyouni I, Ray C, Claramunt C. Spatial models for context-aware indoor navigation systems: A survey. Journal of Spatial Information Science, 2012; 4:85-123.
2. Becker T, Nagel C, Kolbe TH. A multi-layered space-event model for navigation in indoor spaces. In 3D Geo-Information Sciences (pp. 61-77). Springer Berlin Heidelberg, 2009a.
3. Crompton JL, Kim SS. The influence of cognitive distance in vacation choice. Annals of Tourism Research, 2001; 28(2):512-515.
4. Chilakapati Anil Kumar, Srikonda Ramesh, Iyer Vijayalaxmi. Appreciation of Passenger's Intuitive Navigation In 'Ticketing Cum Entrance Lobby' Of Railway Station – A Case Study of Vijayawada Railway Junction, India. NeuroQuantology, 2022; 20(10):4526-4545.
5. Farber S. Urban Sprawl and Social Interaction Potential: An Empirical Analysis of Large Metropolitan Regions in the United States. Journal of Transport Geography, 2013.
6. Freeman LC. "A set of measures of centrality based on betweenness," Sociometry, 1977; 40:35-41.
7. Hall ET. The Hidden Dimension. New York: Anchor Books, USA, 1966.
8. Hillier, Hanson. The Social logic of space. Cambridge: Cambridge University Press, 1984.
9. Huang L, Li Q, Yue Y. Activity identification from GPS trajectories using spatial temporal POIs' attractiveness. In Proceedings of the 2nd ACM SIGSPATIAL International Workshop on Location Based Social Networks, 2010, 27-30.
10. Lynch. The Image of the City. Cambridge: MIT Press, 1960.
11. Nagel C, Becker T, Kaden R, Li K, Lee J, Kolbe TH. Requirements and space-event modeling for indoor navigation. Tech. Rep. OGC 10-191r1, Open Geospatial Consortium Discussion Paper, 2010.