International Journal of Applied Engineering Research

Fuzzy-MICMAC Analysis of Enablers m-learning over 5G Networks

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Date of Submission: 13th July 2021 Revised: Accepted: 19th October 2021

How to Cite: **Kala, L., Shahul Hameed, T. A. and Pramod, V. R. (2021). Fuzzy-MICMAC Analysis of Enablers m-learning over 5G Networks. International Journal of Applied Engineering Research.**

Abstract - **This research aims to apply the Fuzzy-MICMAC method to analyse enablers of 5G networks, which make them suitable for application in mobile learning (m-learning). It depends on the interrelations among the selected enablers. Here triangular Fuzzy ranges are considered in a progressive step size of 0.1. Mean values of the responses collected from a large group were calculated. Results thus obtained prevailed the role of the Fuzzy logic approach for this type of study as a tool to analyse the percentile score of intermediate states too, to acquire knowledge of the system under consideration. Noticeable variations in results were observed with the Fuzzy–MICMAC method, with better precision than existing ones.**

Index Terms - 5G enablers, Fuzzy, ISM, MICMAC, mobile learning.

INTRODUCTION

Nowadays, with ubiquitous network access, and infinite connectivity, the internet is no longer a tool for communication, but the most potent force for learning and innovation, since the printing press. A future where the advent of 5G, with its abundant bandwidth, high data rate and low latency, provides a fast but easily accessible platform that reduces the constraints of place, time and geography. 5G allows people to remotely access high-quality opportunity and education provisions at any place, any time basis [1]. It provides a vast range of applications in various walks of life, ranging from simple mobile communications to IoT based applications and Virtual reality and Vehicular networks or V2V communication are a few most enthusiastic applications of 5G [2,3]. 5G is not an incremental advance on 4G, but a paradigm shift with high frequency and huge bandwidths, ample set of antennas and enormous device densities [4]. This work aims to analyse and model the system enablers of 5G networks so that a mobile learner can utilise the added features of 5G networks [5,6] over the existing 4G-LTE networks. Only around 50 countries have switched their operations to 5G networks. The rest of the countries are also expecting to deploy this incredibly sophisticated technology to their citizens shortly. Here the application selected is mobile learning. The authors are keen to analyse the features of this 5G technology, which enhances the learning experience of a distant learner depending on mobile handheld devices and mobile networks. This emerging technology and the rapid development of information and communication technology act as essential elements in day-to-day life. However, the sudden COVID-19 pandemic outbreak saw extensive and complete lockdown days, which forced people to migrate and confine themselves to the online world. This called for a technology that is needed for a seamless online experience. This study shows its significance, especially within the COVID and post COVID era of teaching and learning processes, with the support and advancements of mobile learning platforms and technologies. So research in this direction is the need of this hour and the motive of this work. As most of the 5G network enablers are supportive factors to the chosen topic for the research, it is pretty interesting to see the output of this study and the numerous ways it supports m-learning.

METHODOLOGY

This research aims to establish inter-relationships among enablers of 5G technology that support m-learning with Fuzzy-MICMAC analysis. It is not easy to establish any relation among ill-structured mental

models to a structured mathematical model. Enablers of 5G networks were collected from literature, publications, textbooks, and websites. Eighteen enablers are identified and submitted to experts from different grounds, such as the networking field, service providers, academicians, and end-users. After a thorough study conducted through various modes of discussions with experts, end-users, designers, and learners and after further deliberations and final round of meetings, twelve enablers were shortlisted and labelled as Enablers of 5G (E5G). Here, it is entitled E5G1 to E5G 12, respectively. The shortlisted enablers are shown in Table I, column 2.

Fuzzy-MICMAC ANALYSIS

More accurate analysis is possible by moving with the Fuzzy values of intermittent states while analyzing a system. Fuzzy-MICMAC [7] is another version of the multi-criteria decision-making tool, while only binary logic 0 and 1 were considered in the adjacent and reachability matrix of ISM [8]. In Fuzzy-MICMAC, many discontinuous levels were taken depending on the depth of variations in the interrelationships among the elements under study. Since ISM evaluation solely depends on the observations and information provided by the decision-making experts in the field, and some of the factors will not fall in the Yes or No category, the Fuzzy's more précised approach is highly appreciated. After further deliberations, the Fuzzy values of the influential factors of enablers of 5G are calculated and tabulated. Fuzzy triangular membership functions were measured for this work, and the mean value of the collected data was assigned against each enabler of 5G. Its interrelations are given in the form of a matrix, as shown in Table I, termed as Fuzzy-Final Reachability Matrix (FFRM) or simply Fuzzy-FRM matrix.

Here the selected application is m- learning [9] over 5G networks using mobile handheld devices. It enables the user to be active while moving [10]. With the impact of selected enablers, the process becomes far more innovative compared to the prevailing tools. In this study, Fuzzy-MICMAC analysis was performed over the Fuzzy-FRM matrix. The power analysis of the 12 x 12 matrix was performed. For each power matrix, both the row sum and column sum are found out and tabulated. The step was repeated till the stagnation is reached. In this particular case, on the sixth power of this Fuzzy Power matrix, stagnation is reached. The row sum and column sum of each power matrix for all six states from the first level till stagnation were tabulated in Table II and termed Fuzzy Stagnation Matrix (FSM).

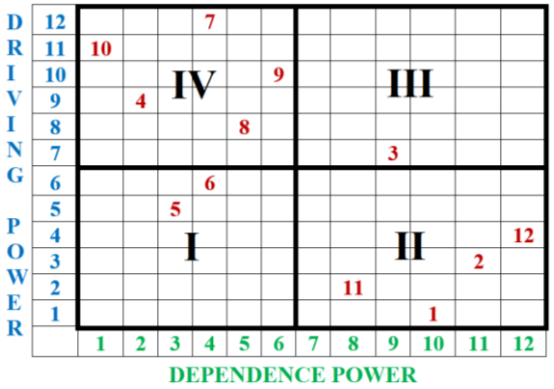
TABLE I
FUZZY-FRM MATRIX-5G

E5G Code.	Enablers of 5G Network	1	2	3	4	5	6	7	8	9	10	11	12
E5G-1	Affordable cost	1	0	0	0.3	0.3	0	0	0.1	0.3	0	0.1	0.9
E5G-2	More reliable	0.7	1	0.9	0.5	0	0.1	0.5	0.3	0.5	0.1	0.3	0.7
E5G-3	Safe and Secure.	0.3	0.7	1	0.5	0.5	0.1	0.7	0.1	0.7	0.3	0.5	0.9
E5G-4	Fully wireless	0.2	0.7	0.7	1	0.5	0.5	0.5	0.7	0.7	0.7	0.7	0.9
E5G-5	High Speed	0.5	0.7	0.7	0.5	1	0.5	0.5	0.1	0.3	0	0.1	0.7
E5G-6	High Capacity	0.5	0.7	0.7	0.5	0.5	1	0.7	0.5	0.3	0.1	0.5	0.9
E5G-7	High Efficiency	0.9	0.9	0.7	0.5	0.9	0.7	1	0.5	0.5	0.7	0.7	0.9
E5G-8	Low Latency/Less Delay	0.5	0.7	0.1	0.7	0.5	0.7	0	1	0.7	0.5	0.7	1
E5G-9	Huge Data Rate	0.9	0.9	0.7	0.5	0.3	0.7	0.7	0.7	1	0.5	0.7	0.9
E5G-10	Abundant Bandwidth	0.7	0.9	0.7	0.2	0.7	0.7	0.7	0.7	0.9	1	0.5	0.9
E5G-11	Uninterrupted connectivity	0.9	0.3	0.1	0	0.3	0.5	0.3	0.3	0.1	0.5	1	1
E5G-12	Global acceptability	0.3	0.9	0.1	0.3	0.1	0.1	0.3	0.7	0.3	0.3	0.5	1

TABLE II
FUZZY-STAGNATION MATRIX-5G

No.	R1	C1	R2	C2	R3	C3	R4	C4 (* 10^3)	R5 (* 10^3)	C5 (* 10^3)
1	6	8.3	30.83	41.66	156.414	210.6480	788.168	1.0606	3.9689	5.34
2	5.4	5.7	27.12	26.91	134.641	135.212	678.11	0.6787	3.4111	3.4159
3	2.1	5	11.3	24.23	55.181	121.687	278.768	0.6113	1.4007	3.0773
4	6.8	4.2	34.73	22.21	174.8	111.425	880.404	0.5621	4.4315	2.8298
5	4.8	4.9	24.56	24.04	124.38	122.203	627.051	0.6166	3.158	3.107
6	3.9	4.7	19.26	24.52	96.472	122.579	485.154	0.6177	2.442	3.1085
7	4.5	4.4	22.14	22.98	110.844	116.586	557.916	0.5875	2.8078	2.9582
8	5.2	6.5	25.75	33.79	130.154	170.701	655.097	0.8613	3.2993	4.3379
9	6.3	5.1	31.54	25.69	159.29	130.141	800.621	0.6552	4.032	3.2992
10	5.9	3.3	30.72	15.74	155.697	77.573	782.402	0.3889	3.9399	1.9549
11	4.1	4.5	19.6	21.42	98.511	106.165	494.219	0.5329	2.488	2.68
12	4.7	3.2	22.99	17.35	116.11	87.574	585.472	0.4407	2.9479	2.2181

Then the driving power-dependence values of each enabler were devised and tabulated from this stagnation matrix. Its coordinate graphical representation is plotted in figure 1, termed the driving power dependence graph [7, 8]. This diagram shows that E5G5 and E5G6 have less driving power and are independent of other factors. Interdependence. E5G4 and E5G10 had more driving power and less dependence. Parameters E5G4, E5G7, E5G8, E5G9 and E5G10, are in the fourth quadrant, which are the drivers of the system that influence the other parameters. E5G3 is the only parameter observed in the HH class in the third quadrant, with high driving power and high dependence on other factors. E5G1, E5G2, E5G11, and E5G12 are in the second quadrant and have high dependence and low driving power. They are the dependent parameters that depend on other parameters, but the reverse is not true since it has only very low driving power.



This sort of Fuzzy-MICMAC analysis furnished a well-balanced reflection on the carefully chosen elements. All this research work was implemented using MATLAB. The known triangular form of representations, selecting triangular membership functions, algorithmic details, mathematical representation, and other steps involved in Fuzzy analysis was omitted in the explanation to make this paper a concise one.

FIGURE 1
FUZZY-MICMAC –D-D PLOT

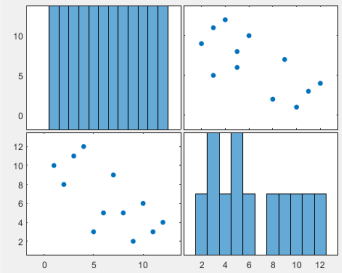
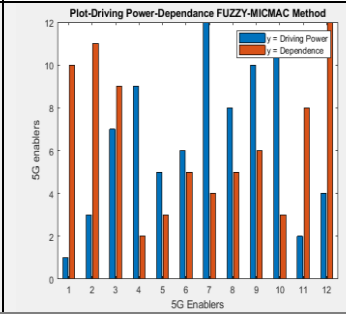
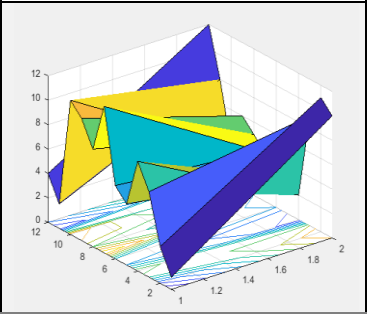
METHOD	SCATTER PLOT	BAR CHART	SURFACE PLOT
Fuzzy-MICMAC			

FIGURE 2
FUZZY-MICMAC ANALYSIS PLOTS

The tabled data is analyzed and results plotted. The correlation analysis was performed, and a graphical representation of the 3D-correlation plot of Fuzzy-MICMAC is given in figure 3. It is a 12x12 point plot with 144 data points taking values with odd fractions starting from 0.1 to 0.9, in step sizes of 0.2. Intermittent values were also included in a few instances. Very rarely, even fractions may also present in the data matrix. All variations from 0 to 1 in Fuzzy steps are evident from the plot at any observational time. The diagonal values indicate unity, which corresponds to the autocorrelation of various enablers. The rest of the points in the 3D plot shows cross-correlation between (i, j) and (j, i) pairs. Analysis in three different forms was performed, and its mathematical plots are given in figure 2. Scatter plots indicate the variations in the alignment of corresponding values with one to one correspondence. A one-to-one relationship between each pair of driving-dependence power relation is well understood from the bar plot sketch. The surface 3D plot provided an idea of flatness in the curve, where corrugations are further flattened, compared to that with simple logic values of 1's and 0's. So it can be inferred that the Fuzzy-MICMAC method gives a more dependable analysis. So with triangular fuzzy values, the results become confined and accurate.

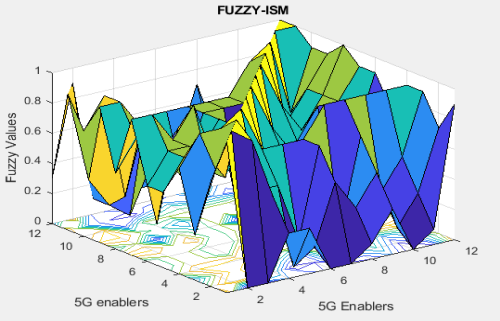


FIGURE 3
CORRELATION PLOT- FUZZY-MICMAC

CONCLUSION

This work composes a study on Fuzzy-MICMAC analysis of 5G enablers to make it suitable for remote mobile applications such as 5G-radio, vehicle-to-vehicle communication, machine-to-machine communication, augmented reality, IoT applications, medical applications in healthcare, etc. In this work, particular emphasis was given to m-learning with the selected parameters of enablers of 5G networks. This era of the COVID pandemic caused people to learn, communicate, interact and work virtually without any face-to-face interaction. In a way, this catastrophe helped show us the lucrative side of online learning. It paved the way for the expeditious development of technology necessary to provide innovative and resilient solutions to combat the disruption caused by the pandemic. This called for the proliferation of 5G network systems to provide the necessary bandwidth, data rates and low latency needed for a seamless online experience. The pandemic era of work or study from home enhanced the need, appropriateness, and importance of this research track. A study in the Technological University in Kerala, India, revealed that, out of around two lakh students, more than 80% of students depend on smartphones as the device to connect to their online classes from their place of residence. The problems faced by the teaching-learning community were the lack of network coverage, connectivity issues, latency, low voice quality, intermittent breakage of online live streaming, etc., with the existing 4G-LTE system or even 3G systems in certain areas. So a study on the 5G system, which is an answer to all these inhibitors of current technologies, is an urgent need of the hour. In the present study, the authors could prove that Fuzzy-MICMAC is a better choice over the direct ISM-MICMAC analysis to establish the relationships between pairwise comparisons of the enablers of 5G technologies. So the Fuzzy-MICMAC method is proved to be an upgraded method for analyzing the enablers of 5G, with more precise results than the existing methods, which will revolutionize the mode of m-learning on the introduction of 5G technology. This study will also help the technocrats and service providers to consider these dependent and driving factors while designing networks and devices which will enable m-learning.

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