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Research Article

Formulation of Interpretive Structure modeling of Gastrointestinal Motility

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Abstract

Understanding of Gastrointestinal Motility is an immense and complex subject that is out of scope of various technological sciences and confounding as there are major and minor regulators, which may interact in this mechanism and makes it a vital part of digestion of food and transit within GI system. Overall, a chief mechanism postulating in functioning of gastrointestinal system.

The purpose of this paper is to identify the key elements/attributes/enablers of gastrointestinal motility and find a functional relationship between them. In this paper, a framework is developed using interpretive structural modeling (ISM), for associating different enablers with each other during Gastrointestinal Motility.

Keywords: ISM, Gastrointestinal Motility, Digestion, propulsion of food

1. Introduction

For many years, "Gastrointestinal Motility" has been a vast and complex topic of research and even far more complex in understanding the interaction and relationships of different elements in this very coordinated and a desired pattern producing activity. The GI system prepares food via a certain sequence of events and produces energy required for an individual to preserve life. This includes breaking down of food particles and mixing with gastrointestinal fluids to form chyme and bolus; transport them locally and within the organ of the GI system. Gastrointestinal motility participates as major natural processes in digestion defined above, and includes linen movement in of the GI system, to attain functions like inter-organ propulsion, mixing of food and intra-organ propulsion. These causes are very complex in nature and encompasses a very integrated pattern using different inputs such as ENS and CNS. As a whole, the term motility encompasses both motor activity and transportation. J. E. Kellow highlighted the following role of ENS & CNS in GI system:

1) Alteration of motility according to local coordinate.
2) Co-ordination of motility within and between G.I tract regions.
3) Integration of Motility with other physiological state. (wake, sleep)
4) Appropriate Interaction between motility and other G. I tract functions.[1]

ISM is an Interactive Learning procedure, by which different variables are entertained to construct the structural model. The basic idea to utilize this methodology is to utilize practical experiences and knowledge of a complicated system having several sub-systems (elements) and construct a multilevel structure model[2]. This paper tries to develop an interpretive structural model underlying relationship between various factors involved in GI motility. This model will suffice the need for implementation of technologies utilized in different scope of sciences.

2. Literature Review

The relation between different microstructure, secretion of endocrine and exocrine organs and control system been always a subject of curiosity. There are many efforts, to find experimentally the role of a particular element on motility or Migrating Motor Complex. As per the K.W. Romanski, the element of controlling or affecting motility is still to be recognized, further, he had put emphasis on the CNS as main controlling factor of Motility coupled with the PNS containing ENS, Neuro-hormonal agents, hormonal influences and luminal influences[3]. The motor activity is cyclic in nature and can be seen by cyclic myoelectric activity, which reflects motor activity of the tract. So by amplitude and frequency under consideration can easily be calculated by motor activity pattern as discussed by Sarna *et al*. Further, he found that motility is aided by the coordinated secretion of enzymes, acid and bicarbonates[4]. The effect on the bodies' states i.e sleep or sleeplessness, and control of CNS/ENS on motor activity during the state was studied by the Gorard *et al*[5]. The composition of Bolus, enjoy relation through their contents, i.e. fat calorific value, etc. with motor activity and it was found that they share inverse proportional relation in study Soffer *et al*.[6]

Various research has been conducted in the field of Nurohormonal reception by control of these by inducing drug to regulate the particular hormone. Neno *et al* work in the direction of motility determine by Somalastatin & Cholesystokinin octapeptide is a great support[7].

The effect of ENS was studied by the Johnson *et al*. On Jejunum after denervation and found that there was observed motor activity, even when Jejunum get automatically denervated[8].

Role of the CNS was well studied by Wang *et al* using strain gauge at serosa and intubation in vein and he demonstrated the variation with the interference of CNS[9]. The effect of hormonal influences was studied by Valori *et al*. In his work of finding stern and prokinetic drugs to study the essence of the musculature of motor activity[10]. The survey, conducted on manometric, my electric, pharmacological and vagatomy studies by Zenilman, found the effect of innervations of different parameter on gastrointestinal mobility[11]. Bakery *et al* had conducted studies to determine the relation of the non adrenergic, and non-cholinergic [NANC] on the mobility of stomach of rabbit provide a great lead to understand their role in human G.I. Tract motility[12].

The study of Neurotransmitters was conducted by Gershon in his work on understanding physiology of the bowl after variation of 5-hydroxytryptamine in the gut by activating it through drugs[13]. Hansen *et al*. Work on gut to study the outcome of Serotonin by taking Manometric readings after inducing drug and found a short span adverse effect on motility[14]. The purpose of Mu-Opioid Receptor was evaluated by Kirsten *et al*. And found that it has a great purpose in controlling abnormal motility by playing the role of receptor of motility controlling[15]. Hormonal influences were studied by Dominguez-Munoz *et al* by controlling pancreatic secretion which has a definite role in gastrointestinal activities for which he placed pressure ports for manometer readings so that effect may be calculated after the release of pancreatic juices and observed that initiation of motility in duodenum[16]. Similarly the issue of intra-gastric acidification was found in phase III of MMC in inhibiting motor activity by Hans *et al*. The luminal pH balance also has an effect on motor activity as found by Woodti *et al* through their work at duodenal pH governing by using drugs[17]. The above evidences, we can access the effectors of motility pattern and group them under different heads for ease study of analysis. On the basis of Motility pattern recognition two factors were measured by Kellow *et al*. In their findings and accordingly recommended to access Motility pattern by the frequency and velocity at different location[1].

3. Methodology

The 25 variables under consideration in this study have been identified from the literature review and the opinion of the experts, both from the medical industry and the academia, constricting the scope of for the parts after 1/3 portion of esophagus to end of the large intestine. Through a questionnaire, survey on motility pattern and influence of these variables on each other has been identified. The outputs of the questionnaire survey together with the expert opinion were used in developing the relationship matrix

Considered agility attributes are grouped in different Human body system domain (HBSB) and Motility pattern bases (MPB). In the study described here, respondents were asked to indicate the pairwise relationship of these HBSD and MPB. Few close-ended questions related to the individual profiles were also included in the questionnaire. To achieve a framework through ISM contains following steps:

1. Identification of elements, 2. Establishing a contextual relationship between elements, 3. Developing a structural self-interaction matrix (SSIM) of elements, 4. Developing a reachability matrix from the SSIM, 5. Partitioning of a reachability matrix into different levels, 6. Draw a directed graph (DIGRAPH), to remove transitive links, 7. Conversion of the resultant digraph into an IS, 8. Review of the ISM model to check for conceptual inconsistency[18, 19].

For this purpose a relationship between the variables is computed as "Variable (i) is help in the functioning of the variable (j) or not" and the different variables are:

1	Motility Frequency	14	Hydrostatic force (Gravity)
2	Motility velocity	15	Esophagus
3	Bolus	16	Stomach
4	Chyme	17	Small Intestine
5	Mixing	18	Large Intestine
6	Propulsion	19	Extrinsic gastrointestinal innervation
7	Inter-organ propulsion	20	Intrinsic gastrointestinal innervation
8	Sphincter / Valve Actions	21	Neurohormonal receptors
9	Muscularis mucosae	22	Mechno-receptors
10	Muscularis propria	23	Electro- mechanical coupling
11	Interstitial cells of Cajal	24	luminal factors
12	Muscular Contraction	25	Hormonal Influences
13	Muscular relaxation		

The outcome of this step SSIM are shown in figure 1 the relationships between the variables are as follows[20]:

V - Variable i will help achieving variable j;
A - Variable j will be achieved by variable i;
X - Variables i and j will help achieve each other;
O - Variables i and j are unrelated

Figure –1: SSIM

	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
1	O	A	O	O	O	A	A	O	O	O	O	X	A	A	O	A	A	X	X	X	X	A	A	X
2	O	A	O	O	O	A	A	O	O	O	O	A	A	A	A	A	A	X	X	X	X	A	A	
3	O	A	O	A	A	O	A	O	O	O	O	A	A	A	O	O	O	O	O	O	A	V		
4	A	A	O	A	A	O	O	A	A	A	O	O	A	A	O	O	O	A	A	O	A			
5	A	A	A	A	A	A	O	O	A	A	O	A	A	A	A	A	O	O	O					
6	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	X	O					
7	A	A	A	A	A	O	A	A	A	A	A	O	A	A	A	A	A	X						
8	A	X	A	A	A	A	A	A	A	A	A	O	A	A	A	A	O							
9	A	A	A	O	A	A	O	A	A	A	A	O	A	A	X	O								
10	A	A	A	A	A	A	A	A	A	A	A	O	A	A	X									
11	O	O	O	O	O	X	X	A	A	A	A	O	A	A										
12	O	O	X	O	O	X	X	A	A	A	A	O	X											
13	O	O	X	O	O	X	X	A	A	A	A	O												
14	O	A	O	O	O	O	O	A	O	O	A													
15	A	A	A	A	A	O	A	O	O	V														
16	A	A	A	A	A	A	A	O	X															
17	A	A	A	A	A	A	A	V																
18	A	A	A	A	A	A	A																	
19	X	O	V	X	X	X																		
20	X	O	V	X	X																			
21	O	O	O	O																				
22	O	X	O																					
23	X	X																						
24	O																							

The initial reachability matrix for this SSIM is shown in figure 2 and this table forms the basis of the following rule[19]:

- If the (i, j) entry in the SSIM is **V**, the (i, j) entry in the reachability matrix becomes **1** and the (j, i) entry becomes **0**.
- If the (i, j) entry in the SSIM is **A**, the (i, j) entry in the reachability matrix becomes **0** and the (j, i) entry becomes **1**.
- If the (i, j) entry in the SSIM is **X**, the (i, j) entry in the reachability matrix becomes **1** and the (j, i) entry also becomes **1.**
- If the (i, j) entry in the SSIM is **O**, the (i, j) entry in the reachability matrix becomes **0** and the (j, i) entry also becomes **0**.

Figure – 2: Initial Reachability Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
9	1	1	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0
12	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	1	0	0
13	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	1	0	0
14	1	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
16	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0
17	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0
18	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0
19	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1
20	1	1	0	0	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1
21	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	0	0	0
22	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	1	1	1	1	1	1	0	1	0	1
23	0	0	0	0	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0	0	0	0	1	1
24	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	0
25	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1	0	1

Transitivity is also marked as per the basic assumption in ISM which states that if element A is related to B and B is related to C, then A is necessarily related to C[18]. The driving power and dependence power are measured by finding numbers of variable (including itself), which are helped. On the other hand dependence power is evaluated by the total number of variables (including itself), by which help is sought in functioning on this basis, the final reachability matrix is prepared as shown in figure 3.

Figure – 3: Final Reachability Matrix

	6	8	7	2	5	1	10	4	9	11	16	3	12	13	17	18	19	20	15	23	14	22	24	25	21	
19	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	21
20	1	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	1	1	19
24	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	0	0	1	1	1	1	1	0	0	18
12	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0	16
13	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0	16
21	1	1	1	0	1	0	1	1	1	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	15
22	1	1	1	0	1	0	1	1	0	0	1	1	0	0	1	1	1	1	1	0	0	1	1	0	0	15
23	1	1	1	0	1	0	1	0	1	0	1	0	1	1	1	1	0	0	1	1	0	0	1	1	0	15
25	1	1	1	0	1	0	1	1	1	0	1	0	0	0	1	1	1	1	1	1	0	0	0	1	0	15
15	1	1	1	0	1	0	1	0	1	1	1	0	1	1	0	0	0	0	1	0	1	0	0	0	0	12
16	1	1	1	0	1	0	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	12
17	1	1	1	0	0	0	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	12
18	1	1	1	0	0	0	1	1	1	1	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	11
11	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	10
10	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7
8	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7
9	1	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
2	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
5	0	0	0	1	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5
7	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
14	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	5
3	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
6	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	21	20	19	17	17	16	15	14	13	11	10	9	9	9	9	9	8	8	7	7	5	4	4	4	3	

Dependence Power

Driving Power

The next step is of partition of the conical reachability matrix which is done by decision of level. From the final reachability matrix, the reachability and antecedent set for each variable is found. The reachability set consists of the element itself and other elements, which it may achieve, whereas the antecedent set consists of the element itself and the other elements, which help in achieving it. The intersection of these sets is derived from all constituents. The element for which the reachability and intersection sets are same is the top-level element in the ISM hierarchy. Once the top-level element is identified, it is separated out from the other elements. Then, the same process finds the following level of elements. This process goes on till the levels of each factor are identified[21] figure 4.

Figure – 4: Iteration 1

Variable	Reachabilty set	Antecedent set	Intersection set	Level
1	1 2 5 6 7 8 14	1 2 3 4 5 6 7 8 9 10 12 13 14 19 20 24	1 2 5 6 7 8 14	I
2	1 2 5 6 7 8	1 2 3 4 5 6 7 8 9 10 11 12 13 14 19 20 24	1 2 5 6 7 8	I
3	1 2 3 4	3 5 12 13 14 19 21 22 24	3	
4	1 2 4	3 4 5 7 8 12 13 16 17 18 21 22 24 25	4	
5	1 2 3 4 5	1 2 5 9 10 11 12 13 15 16 19 20 21 22 23 24 25	1 2 5	
6	1 2 6 8	1 2 6 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	1 2 6 8	I
7	1 2 4 7 8	1 2 7 8 9 10 11 12 13 15 16 17 18 19 21 22 23 24 25	1 2 7 8	
8	1 2 4 6 7 8 24	1 2 6 7 8 10 11 12 13 15 16 17 18 19 20 21 22 23 24 25	1 2 6 7 8 24	
9	1 2 5 6 7 9 11	9 11 12 13 15 16 17 18 20 21 23 24 25	9 11	
10	1 2 5 6 7 8 10 11	10 11 12 13 15 16 17 18 19 20 21 22 23 24 25	10 11	
11	2 5 6 7 8 9 10 11 19 20	9 10 11 12 13 15 16 17 18 19 20	9 10 11 19 20	
12	1 2 3 4 5 6 7 8 9 10 11 12 13 19 20 23	12 13 15 16 17 18 19 20 23	12 13 19 20 23	
13	1 2 3 4 5 6 7 8 9 10 11 12 13 19 20 23	12 13 15 16 17 18 19 20 23	12 13 19 20 23	
14	1 2 3 6 14	1 14 15 18 24	1 14	
15	5 6 7 8 9 10 11 12 13 14 15 16	15 19 21 22 23 24 25	15	
16	4 5 6 7 8 9 10 11 12 13 16 17	15 16 17 19 20 21 22 23 24 25	16 17	
17	4 6 7 8 9 10 11 12 13 16 17 18	16 17 19 20 21 22 23 24 25	16 17	
18	4 6 7 8 9 10 11 12 13 14 18	17 18 19 20 21 22 23 24 25	18	
19	1 2 3 5 6 7 8 10 11 12 13 15 16 17 18 19 20 21 22 23 25	11 12 13 19 20 21 22 25	11 12 13 19 20 21 22 25	
20	1 2 5 6 8 9 10 11 12 13 16 17 18 19 20 21 22 23 25	11 12 13 19 20 21 22 25	11 12 13 19 20 21 22 25	
21	3 4 5 6 7 8 9 10 15 16 17 18 19 20 21	19 20 21	19 20 21	
22	3 4 5 6 7 8 10 15 16 17 18 19 20 22 24	19 20 22 24	19 20 22 24	
23	5 6 7 8 9 10 12 13 15 16 17 18 23 24 25	12 13 19 20 23 24 25	12 13 23 24 25	
24	1 2 3 4 5 6 7 8 9 10 14 15 16 17 18 22 23 24	8 22 23 24	8 22 23 24	
25	4 5 6 7 8 9 10 15 16 17 18 19 20 23 25	19 20 23 25	19 20 23 25	

Now conical matrix with the driving power and dependence power along their level of variable is made, as shown in figure 5.

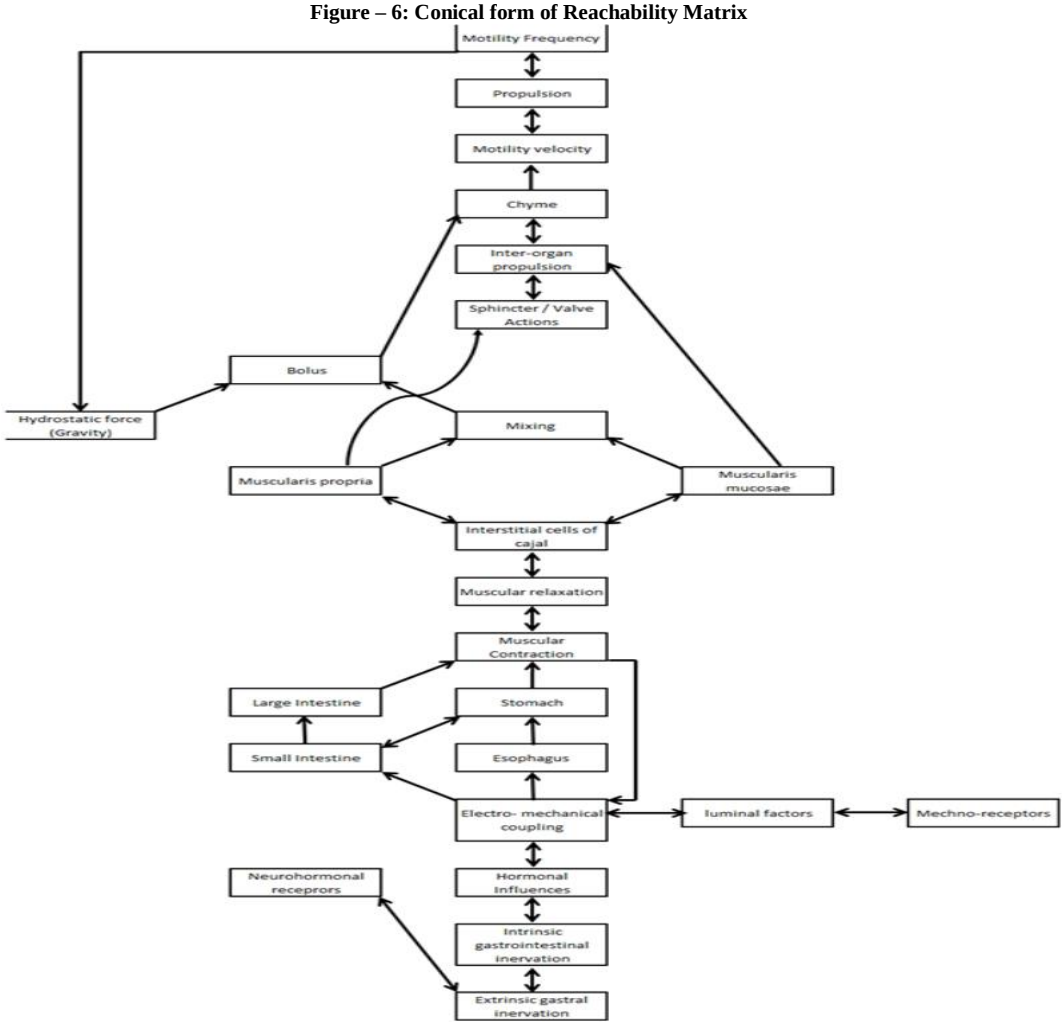
Figure – 5: Conical form of Reachability Matrix

	6	2	1	4	8	7	3	5	14	10	9	11	12	13	16	18	17	15	23	22	24	25	21	19	20	Driving Power	Level
1	1	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	17
2	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	18
6	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	19
4	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16
8	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7	13
7	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	14
3	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	15
5	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	12
14	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	12
11	1	1	0	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	10	9
10	1	1	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	10
9	1	1	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	11
12	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	1	1	16	8
13	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	1	1	16	8
16	1	0	0	1	1	1	0	1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	12	6
18	1	0	0	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	11	7
15	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	12	5
17	1	0	0	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	12	5
24	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	18	3
21	1	0	0	1	1	1	1	1	0	1	1	0	0	0	1	1	1	1	0	0	0	0	1	1	1	15	4
22	1	0	0	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	0	1	1	0	0	1	1	15	4
23	1	0	0	0	1	1	0	1	0	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	15	4
25	1	0	0	1	1	1	0	1	0	1	1	0	0	0	1	1	1	1	1	0	0	1	0	1	1	15	4
19	1	1	1	0	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	21	1
20	1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	19	2
Dependence power	21	17	16	14	20	19	9	17	5	15	13	11	9	9	10	9	9	7	7	4	4	4	3	8	8		
Level	19	20	21	18	15	16	17	13	14	10	11	12	9	9	7	8	5	6	4	3	3	3	2	1	1		

4. Results

Based on conical form of reachability matrix and level partitioning, the initial digraph including transitive links is obtained. After removing indirect link, the final model is developed, as shown in figure 6.

Figure – 6: Conical form of Reachability Matrix



It is observed that CNS, ENS, Hormonal influences, and electromechanical coupling play a driving role in achieving motility. These initiates motility after receiving information from Neurohormonal receptors, luminal factors, and mechano- receptors, as indicated in fig. As these are at the bottom level of the pecking order. The Motility frequency, Motility velocity, propulsion, and Chyme, also depend upon other variables to achieve different motility patterns in the gastrointestinal system and these variables, are at the top of the pecking order. Now if we consider Propulsion, Inter- organ propulsion, Mixing, and Sphincter/ valve action, they depend upon by other variables. On the other hand Muscular contraction, Muscular relaxation, and ICC, provide information to muscularis propria and muscularis mucosae, both in-turn provides a suitable

environment in different organs to target the mechanical function. The whole picture is quite tricky beside digestive system itself, as MPB also helps in achieving lower level HBSD. Motility Frequency helps in making bolus with the help of Hydrostatic forces and Motility velocity help in achieving Propulsion. On the other hand, bottom level HBSD have two ways of interaction with upper level HBSD as CNS gets information from neurohormonal receptors and stomach receive information from the small intestine. Here it is concluded that the influence of one variable on the other is not one sided. CNS and ENS are greatly influencing MPB and HBSD like, Motility frequency, Motility velocity, propulsion, mixing, inter-organ propulsion, sphincter / valve action, ICC, Luminal factors, Muscle contraction, Muscle relaxation, and Mechano receptors associated with motility patterns. From the ISM it is clear that if we concentrate on CNS and ENS inputs, which, if analogous after understanding their function and effects on others than we are able to achieve different function of mechanical digestion directly and hence leaving others like neurohormonal receptors, hormonal influences, histology, and other complex variables for making understanding of gastrointestinal systems easy.

5. Discussion and Conclusion

The present model will serve to increase the awareness of decision makers, while assisting them in better understanding of the interaction and influences amongst different enablers/ elements involved in Gastrointestinal Motility.

It is now clear that ENS and CNS have been found to influence and monitor various attributes like motility frequency and motility velocity within the GI tract assisted by feedback involving Neuro-hormonal receptors and hormonal influences. These inputs activate ICC in eliciting slow wave propagation in various segments of GI, i.e. stomach, small intestine, Large Intestine, enabling rhythmic contraction and relaxation of smooth muscle Muscularis Propria and Muscularis mucosae; thus allowing mixing of food to form chyme and bolus and propulsion within inter and intra organs.

ISM also highlights some direct relationship between hydrostatic force in propulsion of food/chyme from esophagus to the stomach; Also the role of luminal factors like segment geometry / pH balance and wall friction in alteration of mechanoreceptors, which further influence with afferents from CNS and ENS.

More can be learned about identification of quantitative role of all attributes used in this study as their role in GI motility.

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