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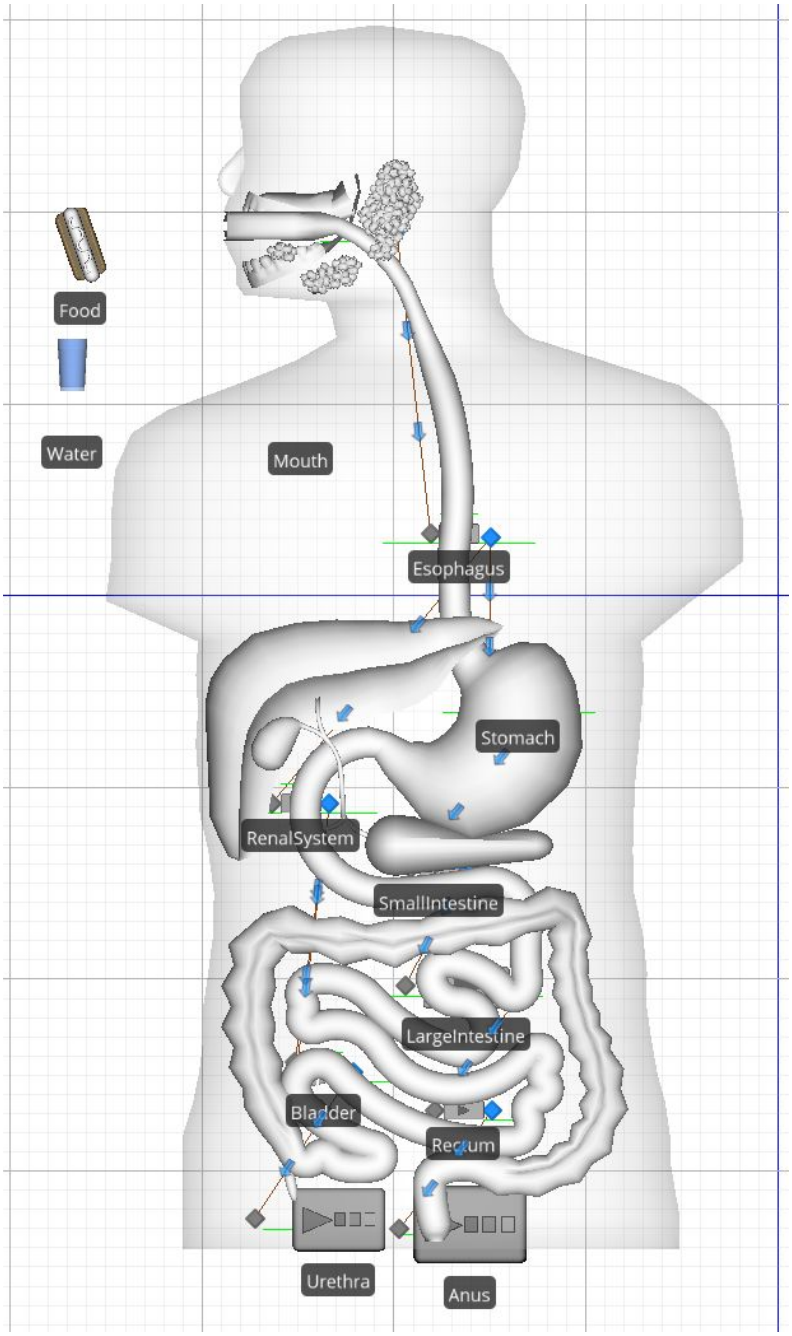
DATA 604 - CUNY MSDA

In Vivo Simulation of the Excretory System In Vitro



a. Background, Purpose, significance:

Currently, in the scope of simulations and modeling, very few (intricate) models exist templating the human body. Those that do exist, explore niche aspects of the human body, created with a specific goal in mind.(i.e. How the muscles in our sphincter work) These models either do not meet practical needs, are publicly unavailable, or require too much knowledge of the human body to be appropriate for others to use.

The purpose of this model is to create a framework for basic human consumable processing in the excretory system (Renal & Gastrointestinal). Setting a bar (albeit at an arbitrarily chosen point) is or could be helpful in the future for both students and researchers alike. Granted I am not a doctor, or a near equivalent, but there exists numerous sources to guide me in the temporal journey to understand the tract our food and water takes before leaving our system. Alternatively; the purpose to creating this model is to show a juxtaposition between the simplicity of our body's in-out system, and the multitude of processes involved between the in, and the out.

The significance of this project is two-fold. To show others that Simio and like-software is not restricted to modeling non-biological queues; and ascertain by proof of expert witness; whether or not it is feasible to model complex (with many unknowns) biological systems.

B. 5 peer-reviewed literature pieces discussing similar models

One of the most widely used journals encompassing digestion time quotas would be Simplified Assessment of Segmental Colonic Transit by Mayo Medical School. They sought to find effects of age, gender, and fiber; and conduct simple measurements of

segmental colonic transit. The model used by this article has four steps, if I were to mimic it in my simulation, I would use 1 source [mouth], 3 servers [Stomach, Small Intestine, Large Intestine]. Using the formula MCT = ⅓(MCT_1+MCT_2+MCT_3) Also known as Mean Colonic Transit time, the researchers here were able to ascertain the mean travel times of different ages and genders (All of which varied significantly). Using this journal, I decided on limiting my model to males and leave out both the kidney and liver as insignificant factors.

The Bowel Habit of Young Children by Weaver & Steiner gave me three critical conclusions. As humans age, their bowel movements become increasingly infrequent. The frequency of a bowel movement rises as water input into the system does. Lastly, the daily bowel action is the norm for adults. A survey of 1455 adults found that 5-7 bowel actions a week is typical and that 99% fell within the limits of 3 daily to 3 per week(This is later corroborated with historical data found on reddit(Due to the lack of relevant publicly available Data, I will admit data found on reddit)).

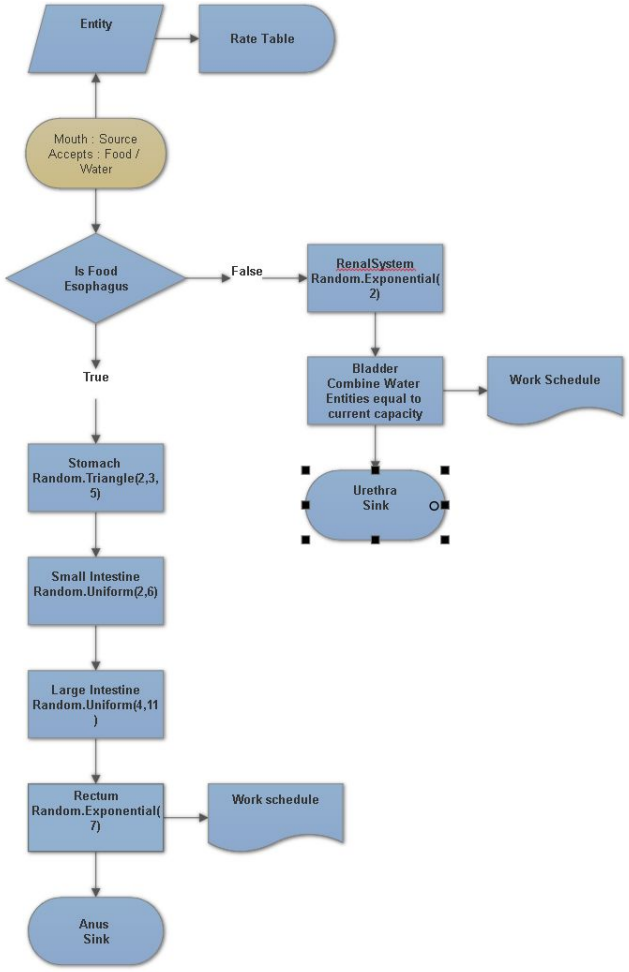
How to interpret a Functional or Motility Test - Colon Transit Study by Kim & Rhee uses the same model as the journal by Mayo Medical. Starting from the source, patients digested 22 radio-opaque markers that were then monitored in intervals by X-ray. The markers were recorded by time and organ (server.) The significance of this journal is two-fold. Exposing incongruent gastrointestinal times internationally. If I am going to use data; it must all come from one continent. It also explicitly states, and corroborates that monitoring the GI tract via stomach, large, and small intestine is standard.

Analytical Modeling for the human digestive system by R.H. Serieg, published by IEEE attempts to study the behavior of the human digestive system based on queueing theory. However verification is still needed and the model is only proposed. The reasoning is that creating an actual, robust, validated and verified model requires a considerable amount of resources. One conclusion is that if such a model were made; it would defeat the current mathematical models based on linear/nonlinear circuit analysis in terms of computational time.

Comparison of gastric emptying of a nondigestible capsule to a radio-labelled meal in healthy and gastroparetic subjects by AP&T suggests that outlying digestive times of indigestible substances is statistically significant enough to raise alarm. The implication of this article is that studying the passage of food or water times could be a key factor in medical research.

C. Flowcharts for modeling

In this proposed model, entities arriving via a rate table, and an exponential distribution of L2. Food travels down the GI tract used by every scientific journal shown. Where as water goes down my proposed renal system.



E. Verification and Validation methods

Goal analysis: as stated in this paper's purpose. My goal was to make a simple human body model. The caveat here is that the human body is anything but simple. In order to achieve any validation or verification I required simple metrics, corroborated by formal studies. This means my *goal* is to create a basic GI tract, that when given an average USA male of age 18-30 numbers; should reproduce entity travel times found in my journal readings. In terms of processing times Ev(stomach) = 2-5 Hours, Ev(small Intestine)=2-6 Hours, Ev(large Intestine) = 4-11 Hours. The average human processing time mouth-to-anus is 15-59 Hours. The discrepancy here is that there is no data found on the time, food spends waiting after processing, in the rectum. So I created a rectum server to serve as a waiting pool. Without a known processing time or predominant biological function other than 'storage,' my goal became to assume the factors that would compose a rectum's activity. *Building the right model* meant cultivating realistic rectum times. A rectum is emptied through the anus in a regulatory fashion. Meaning the perceived key here is to create a work schedule, in which only certain hours of the day (just like in our lives) do we choose to empty the rectum.

I verified the rectums work schedule by referring to sleepfoundation.org's dataset, copying the mean sleep times for the average USA male weekend/weekday. During sleep, both the mouth and rectum are disabled. This added sufficient bulk to food entity's time in system (W).

Validation and Verification for the renal system was much simpler. Studies from the CDC gave us average cups of water consumed daily, how many cups of water your

bladder can hold, and a mean 2 hours to process water. The path for water became an ambiguous (for simplicities sake) renal system; attached to a bladder. A bladder's capacity doubles during sleep; which was maintained through a work schedule.

F. Results of status quo and interventional models

Both models split entities of food and water at the esophagus and both exit through their respective sinks. The status quo model assumes a human is in unbearable pain when a bladder fills, and immediately relieves oneself. It also assumes that a human may empty their rectum twice a day (Morning and night). The interventional model assumes the human may only empty their bowels once in the morning and a bigger interval to do so. It also assumes a human can bear the pain of a full bladder and allows the human to relieve itself only thrice a day. Both models result in goal accomplishments.

Status Quo model keeps food inside the system from 20-62 hours; and keeps water inside the system from 2-6 hours.

Interventional model keeps food inside the system from 28-43 Hours; and keeps water from 4-14 hours.

G. Comparison of results via statistical methods

Statistical results being processed. File will update

H. Conclusions from the modeling

The immediate conclusion here is that a healthy USA male ages 18-30 should not reserve themselves to use the urinal only 3 times a day. It also much more healthy (measured by lower time in system) to give yourself more time to empty your rectum.

On other more extrospective rhetoric, modeling the human body will be mostly inconclusive until current technological feats improve; and we as a collective have more data to analyze, and iterate through in a process of validation and verification. My conclusion is that when modeling anything in the near future, I am to choose an ordinary topic to model, or a well recorded entity.

I. What you've learned

I've learned to how to combine entities, how to use a rate table, deterministic link weights and a great deal on the complexity of the human body. i.e.(Modeling the small intestine as one independent server is absurd, due to influencing factors such as liver and kidney, which are influenced by your renal system.) Creating an accurate, robust model of the human body's excretory functions would be a project many years encompassing.