Summary of Workflow at Ikore (Lidiski Project)

Ese OVIE

June 10, 2021

Acknowledgement of Sources

Contents

Chapter 1

May, 2021

1.0.1 Day Four

Starting work with literature for DEVS

Mem si il y a plusieurs version de léquation SEIR, le premiere modele SEIR choissit c'est prendre apartir de Nakul Chitnis, 2017

$$\frac{dS}{dt} = \Lambda - r\beta\frac{SI}{N} - \mu S \tag{1.1}$$

$$\frac{dE}{dt} = r\beta\frac{SI}{N} - \epsilon E \tag{1.2}$$

$$\frac{dI}{dt} = \epsilon E - \gamma I - \mu I \tag{1.3}$$

$$\frac{dR}{dt} = \gamma I - \mu R \tag{1.4}$$

with $N = S + E + I + R$ and a state space that contains $x = S, E, I, R \equiv x_1, x_2, x_3, x_4$. Which when the equation is rewritten in terms of the new state space variable, we have:

$$\frac{dx_1}{dt} = \Lambda - r\beta\frac{x_1x_3}{N} - \mu x_1 \tag{1.5}$$

$$\frac{dx_2}{dt} = r\beta\frac{x_1x_3}{N} - \epsilon x_2 \tag{1.6}$$

$$\frac{dx_3}{dt} = \epsilon x_2 - \gamma x_3 - \mu x_3 \equiv \epsilon x_2 - (\gamma + \mu)x_3 \tag{1.7}$$

$$\frac{dx_4}{dt} = \gamma x_3 - \mu x_4 \tag{1.8}$$

Characteristics of this model:

1. Model is a logical progression of disease from…susceptibility (S), exposure (E), infection (I), recovery (R)
2. System is nonlinear in the variables S and I. These variable which are the states x_1 and x_3 are coupled. Thye simulation results will have to show these results
3. Autres

Parameters for this model are the following

Table 1.1: Table of parameters.

Parameter	**Description**	**Value**
r	Number of contacts per unit time	a
β	Probability of transmission per contact	b
$r\beta$		0.3
N	Total population size	1000
Λ	Constant recruitment rate	16.667
μ	Per-capita removal rate	0.01667
γ	Per-capita recovery rate	0.1
ϵ	Per-capita rate of progression to infectious state	<< 1

However the linearized model has been obtained via Jacobian method with equilibrium point set as zero. The resulting state space is as follows

$$\frac{df_x}{dt} = \begin{bmatrix} -\mu & 0 & 0 & 0 \\ 0 & -\epsilon & 0 & 0 \\ 0 & \epsilon & -(\gamma+\mu) & 0 \\ 0 & 0 & \gamma & -\mu \end{bmatrix} \begin{matrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{matrix} \tag{1.9}$$

1.1 Week Two

1.1.1 Monday, 10th may, 2021

Audjourd'hui, je commence par lancement de Irritator a partir de "cmd prompt".

Une fois l'ecran irritator ete ourvrir

J'apellee une example parmi d'examples dedan le logiciel c.a.d. l'example de Lotka Voltera avec l'integreteur qss1 qui semble comme je le montre ci en bas

Les questions qui j'ai voudrais poser sont le suivant:

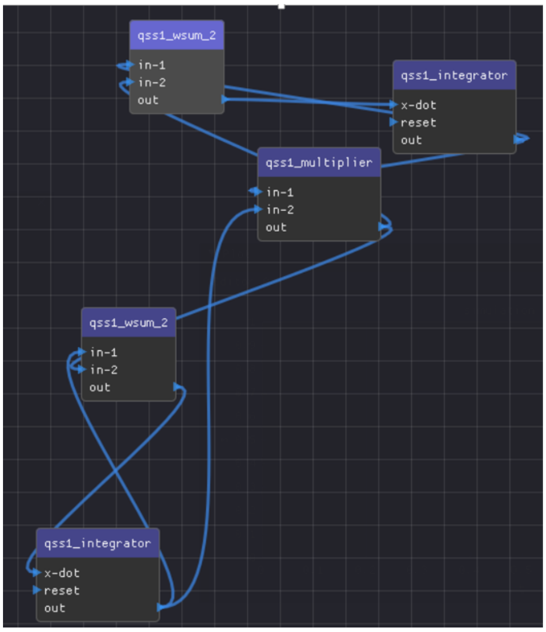

Figure 1.1: L'example de Lotka-Volterra.

1. Apres avoir ouvrir une model dans la liste d'example c.a.d. qss1-lotka-volterra, comment executer cette modele pour avoir une vue du graph/plot
2. Comment fait le connection entre le sortie et l'entre du deux bloques dans la model . Par example entre l'integrateur ´qss1integrator´ et le multiplicateur ´qss1multiplier´.
3. Finalement pour l'instante, qu'est ce la difference entre ´qss1sum´ et ´qss1wsum´

maintenant je l'ecran montre ci-dessous sans idee pour faire le lien entre le bloques (une manual pour le mode d'emploi ou le mode d'utilisation d'irritator peux rendre ca plus facile plus facile)

1.2 Week Three (Semaine Trois)

1.2.1 Monday, 17th May, 2021

Cette semaine commencee avec simulation sur Irritator du modele SEIR. J'ai deaux modele c.a.d. le modele nonlineaire et le modele lineaire.

L'etapes suivre sont les suivant:

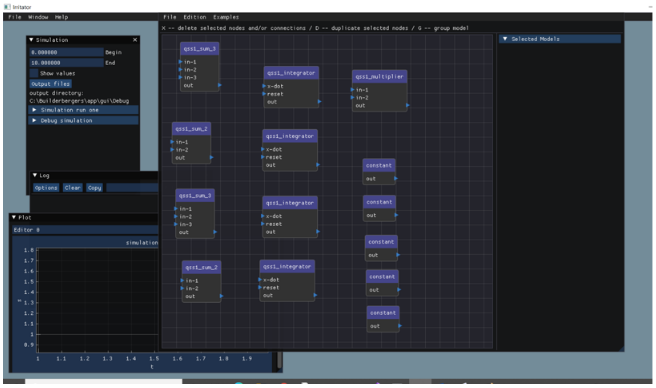

Figure 1.2: L'example SEIR.

1. Etablisement du modele lineaire (equation ()) apartir du modele non-lineaire (linearisation Jacobian)

2. Sassiez le parametres du modele et fait l'execution pour regardez les courbes

3. Faire la meme chose avec le modele Nonlineaire dans equation ()

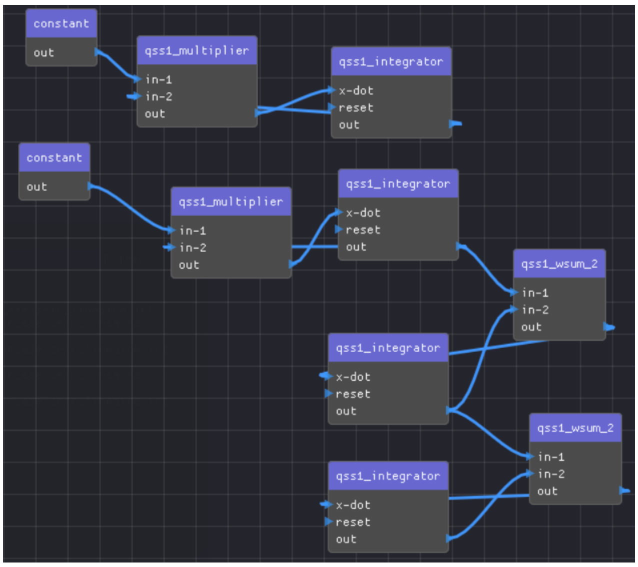

Figure 1.3: SEIR linear model on Irritator.

The linear model of thr SEIR contains ten blocks in allas seen in the Figure ()

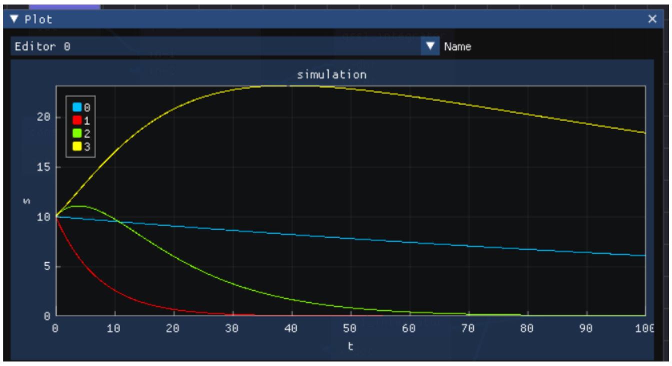

Figure 1.4: SEIR linear Plot.

The plot of the linear system states output shows a convergence of all states given the initial values selected. ALl states settle down to asymptotic regime as time goes to ∞

PS:

Une petite observation paraport le modele SEIR choissit. Il n'y a pas d'entree dans la modele. Plutot je dois prendre en conte l'entree pour la systeme

1.2.2 Thursday, 20th May, 2021

Since I am having challenges getting the nonlinear models to run(for reasons for which I am not clear right now), I have decided to work with a separate model to confirm the issues I am having. I will repeat the model for the linear and nonlinear versions to see if the results are all displayed on plot. This new model has the structure (Singh et al., 2017):

$$\frac{dS}{dt} = -\alpha S(E+I) + aE + bI + cR \tag{1.10}$$

$$\frac{dE}{dt} = \alpha S(E+I) - aE - \beta E \tag{1.11}$$

$$\frac{dI}{dt} = \beta E - \gamma I - bI \tag{1.12}$$

$$\frac{dR}{dt} = \gamma I - cR \tag{1.13}$$

with an associated state space form

$$\frac{dx_1}{dt} = -\alpha x_1(x_2 + x_3) + ax_2 + bx_3 + cx_4 \tag{1.14}$$

$$\frac{dx_2}{dt} = \alpha x_1(x_2 + x_3) - ax_2 - \beta x_2 \tag{1.15}$$

$$\frac{dx_3}{dt} = \beta x_2 - \gamma x_3 - bx_3 \tag{1.16}$$

$$\frac{dx_4}{dt} = \gamma x_3 - cx_4 \tag{1.17}$$

The working parameters are the following

Table 1.2: Table of parameters.

Parameter	**Description**	**Value**
α	rate of pathogen transmission	0.5
β	reciprocal of intrinsic incubation period	0.53
a	rate at which exposed humans become suspectible	0.06
b	rate at which infected human becomes suspectible	0.05
c	probability becoming again suspectible after recovery	0.35
γ	Per-capita recovery rate	0.1
$S(0)$		0.08
$E(0)$		0.07
$I(0)$		0.05
$R(0)$		0.01

1.3 Week four

The nonlinear models are all working. the issue seemed to be the sum block of irritator always requiring that I provide initial values before simulation start

1.3.1 Monday 24th May, 2021

The nonlinear model of the SEIR has twenty seven blocks. The number of blocks increasing by reason of the system complexity in nonlinear configuration.

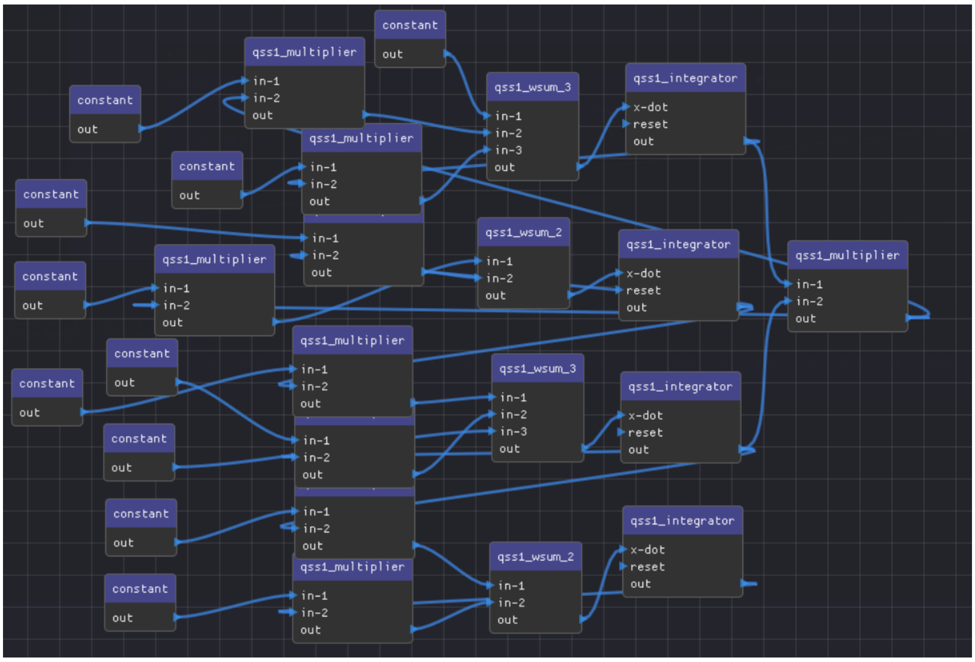

Figure 1.5: SEIR Nonlinear model on Irritator.

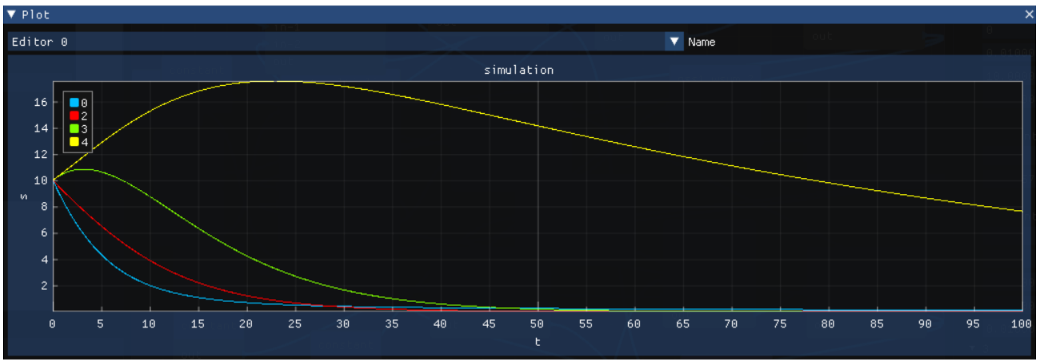

Figure 1.6: SEIR Nonlinear Plot.

the output from the nonlinear system model has been plotted and the results show that the states are also converging asymptotically however slower than the linear SEIR model.

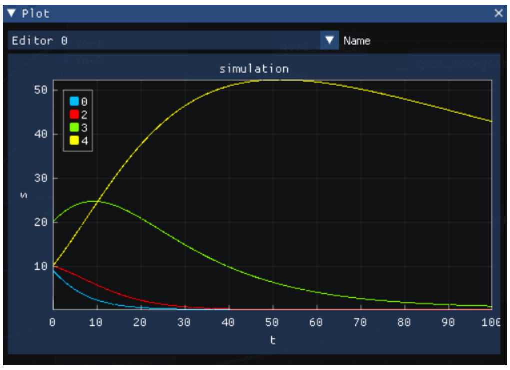

Figure 1.7: Second SEIR Nonlinear Plot.

1.3.2 Friday 28th May, 2021

Submitted the work done on the irritator simulator t Gauthier and Raphael. Awaiting feedback.

1.4 Week five

Tasking by Gauthier to add the developed SEIR models into the irritator simulator. The model definition was t go into the example.hpp header file and the links from the examples dropdown menu goes into the node-editor.cpp file.

After comleteing this task, I had to create a pull request on github. This gave me some challenges.

Dr Joseph requested for means to implement ponline questionnaire. I started looking at USSD implementations on Wednedday of week five and lasted through to friday.

1.5 Week Six

1.5.1 Monday 7th June, 2021

Created the pull request for the modifications made to irritator and Gauthier made comments, requesting corrections to my submission

1.5.2 Tuesday 8th June, 2021

Had a meeting with Raphael and Gauthier

1.5.3 Wednesday 9th June, 2021

I had some issues with my Laptop. Had to do a recovery on my Windows 10 OS.

1.5.4 Thursdayy 10th June, 2021

Started implementing corrections on update to SEIR model added to simulator. Also i have updated this report document to show the parameters values used in the simulation as requested by Gauthier

1.6 Appendix and General discussion of work

The principal idea which the irritator simulator uses is taken from DEVS formalism. DEVS (or discrete event systems specification), is a meta language of some sort for describing dynamic phenomena using its own linguistics and

The distinctive trend of computational science is the continual trend toward greater abstraction and identification of the true underlying commonalities and distinctions between apparently different phenomena. This trend is realized in the evolution of concepts relating to event-oriented simulation that transpired since its inception and which forms the core of the historical perspective on discrete event simulation that we present here (From Discrete Event Simulation to Discrete Event Specified Systems (DEVS) Bernard P. Zeigler and Alexander Muzy, 2017). Other similar efforts at seeking such underlying commonalities include Bond graph and OPM.

Theory of Modeling and Simulation (1976) defined the Discrete Event System Specification (DEVS) formalism as a specification for a subclass of Wymore systems that could capture all the relevant features of the models underlying event-oriented simulations; In contrast, Discrete Time Systems Specification (DTSS) and Differential Equation System Specification (DESS) specify distinct subclasses of Wymore systems

Also look at Moore, Mealy and Markov formalisms. add to this Monte Carlo

According to Hollocks (2008), Tocher's core idea was of a system consisting of individual components, or 'machines', progressing as time unfolds through 'states' that change only at discrete 'events'. Indeed, DEVS took this idea one step further using the set theory of logicians and mathematicians [(Whitehead and Russel, 1910), Bourbaki (1930) and its use by Wymore (1967)

Discrete event systems specification can somewhat be considered to be descriptive of queueing theory or queue systems.

For what Raphae was describing earlier today about the surveillance and control asppects of the LZidistki project, the following description can be made about the system

Surveillance and control model is the global non-modular piece pf the system that holds all other modular atomic pieces togather

For the lidiski project for example

Disease Surveillance and control

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Various disease models e.g.
SEIR
PPR
Newcastle diseaese

each of these modules have their interactions by inputs,states ad outputs

each of these modules can be viewed as single blocks...grey,white or black boxes where only input and output is availabe for interaction within the system

estimators or observers can be used to sample(echantillionage) the detectable states to aid...state deduction, prediction, estimation for computation

Raphael speaks about being able to separate the model from the simulation or simulator means that the abstarct idea which suffieciently describes a physical phenomena be separate from the tool used to investugate it.

1.6.1 DEVS Formalism

This is a formalism consistsing of:
Inputs
States (usually with initial state specified)
Outputs
Time advance function

Bibliography

Nakul, C. (2017). *Introduction to SEIR Models*, Workshop on Mathematical Models of Climate Variability, Environmental Change and Infectious Diseases Trieste, Italy

Singh, S., Srivastava, S.K. and Arora, U. (2017). 'Stability of SEIR Model of Infectious Diseases with Human Immunity', *Global Journal of Pure and Applied Mathematics*, **13-6**, pp.1811–19