MATLAB® Simulation Model on Chaotic Asynchronous Transmitter and Receiver

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INTRODUCTION

- **Background**
  Communication security is now playing an essential role in the functioning of the whole economy, along with the rapid increase of values of the transactions .

- **Goals**
  In this project, a MATLAB simulated communication system based on the application of Chaos theory is constructed to achieve a new approach of secured information transmission.

RESEARCH

- **Chaos theory and chaotic system**

  The three scientific revolutions that would be remembered for the 20th century would be quantum, relativity and chaos[1].

  The most representative characteristic of a chaotic system is its sensitivity to its initial condition, thus an arbitrary small change from the start could lead to a significantly different outcome[2]. These characteristics make chaotic signal an ideal carrier for data transmission.

- **The synchronization of chaotic systems**

  Methods of synchronization, such as linear coupling, Pecoral-Carroll Drive concept and the Lyapunov Stability have been studied, a synchronization method for nonlinear continuous chaotic dynamical systems established by Dr. Andrew Fish was utilized for determining the stability of the error system in the receiver.

- **MATLAB®**

  MATLAB, a powerful tool widely used in academic and research institutions would be used for the algorithms and computing the diagrams for simulation of the transmitter and the receiver[3]. Learning to use MATLAB would be essential to the establishment of the model.

METHODOLOGY

The main approach of the communication system is to use a chaotic oscillator as the transmitter, injecting the information for transmission at the transmitter and recovering it at the receiver.

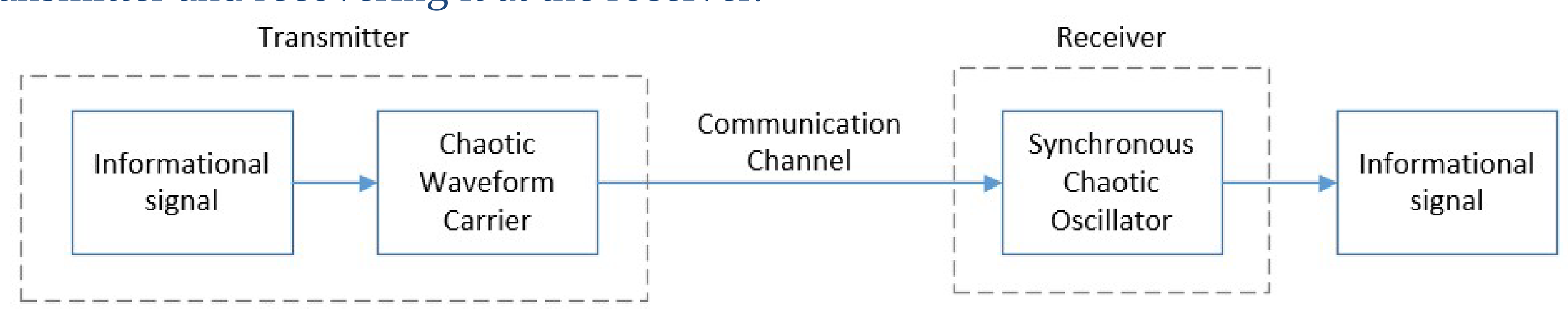

Fig. 1 Overview block diagram of chaotic communication system

After the mathematical model is applied for the communication system, the x, y and e would represent the three different signal states of the transmitter, receiver and the error system, the block diagram would be as shown below:

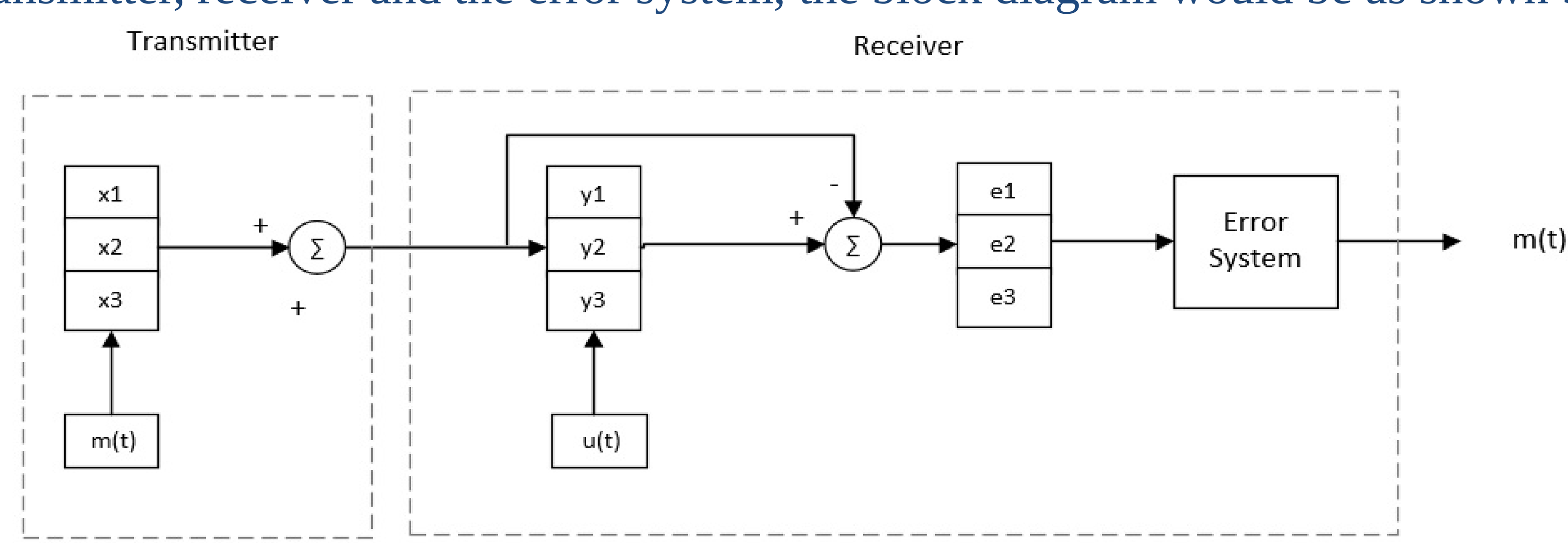

Fig. 2 Block diagram of chaotic communication system with system states

As this simulation model is based using the Rössler system, the following equations corresponds to the transmitter, receiver and the error system accordingly.

Transmitter:
$$\begin{bmatrix} \dot{x}1 \\ \dot{x}2 \\ \dot{x}3 \end{bmatrix} = \begin{bmatrix} 0 & -1 & -1 \\ 1 & 0.2 & 0 \\ 0 & 0 & -5.7 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ x1x3 + 0.2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \mathrm{m(t)}$$

Receiver:
$$\begin{bmatrix} \dot{y}1 \\ \dot{y}2 \\ \dot{y}3 \end{bmatrix} = \begin{bmatrix} 0 & -1 & -1 \\ 1 & 0.2 & 0 \\ 0 & 0 & -5.7 \end{bmatrix} \begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ y1y3 + 0.2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

Error system:
$$\begin{bmatrix} \dot{e}1 \\ \dot{e}2 \\ \dot{e}3 \end{bmatrix} = \begin{bmatrix} 0 & -1 & -1 \\ 1 & 0.2 & 0 \\ k1 & k2 & -5.7 \end{bmatrix} \begin{bmatrix} e1 \\ e2 \\ e3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ y1y3 - x1x3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ u(t) - m(t) \end{bmatrix}$$

The stability of the dynamic error system could be determined by setting the poles a, b and c of the determinants of the error system to the left plane[4].

$$det \begin{bmatrix} s & 1 & 1 \\ -1 & s-0.2 & 0 \\ -k1 & -k2 & s+5.7 \end{bmatrix} = (\mathrm{s-a})(\mathrm{s-b})(\mathrm{s-c})$$

The equation to recover the original information signal m(t) could be drawn from the error system matrix:

$$\mathrm{m(t)} = \mathrm{k1*e1 + k2*e2 - 5.7*e3 + y1*y3 - x1*x3 + u(t)} - \dot{e}3$$

SIMULATIONS

When using MATLAB for mathematic simulation of each system, a variable step Runge-Kutta Method (ode45) to solve differential equations numerically. Below are the plots for the transmitter when m(t)=0.01sin(t) with the initial value of (1,-1,2), and the error system gradually going to zero.

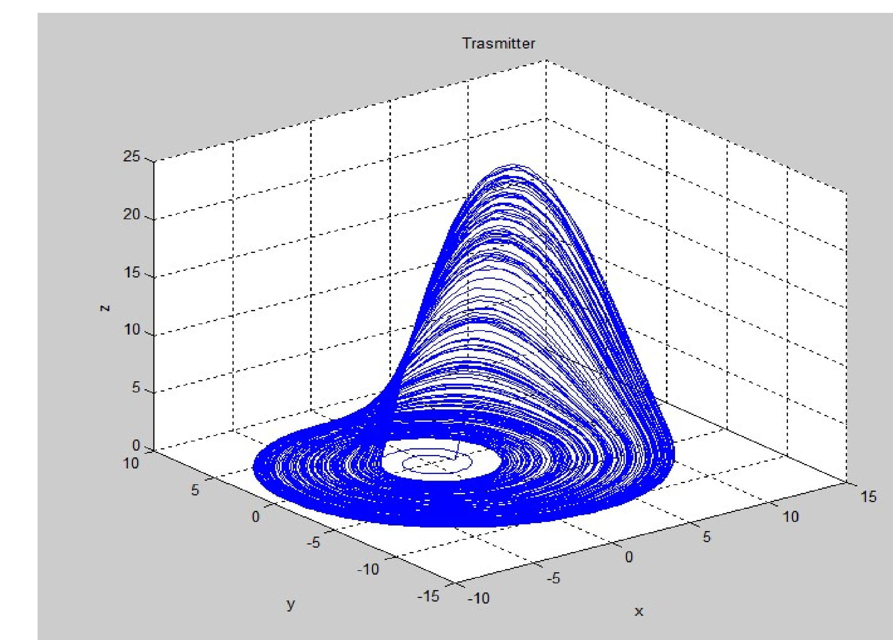

Fig 3. MATLAB simulation model of transmitter

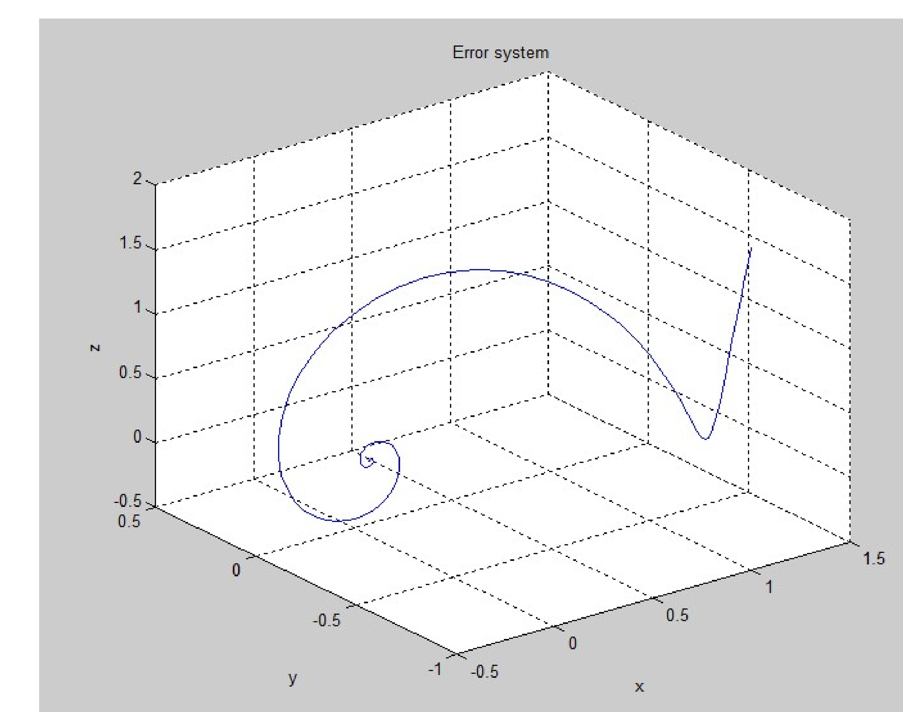

Fig 4 . MATLAB simulation model of error system

REFERENCES

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