Results on Spoked Digits Recognition: simulation

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1 Mathematical model

The mathematical model of setup can be written in terms of time-delay differential equations. It is an electro-optical delay system with one delay feedback line. The system can be modeled by a delay-differential equation,

$$\tau \frac{\mathrm{d}x}{\mathrm{d}t} + x(t) = \beta \sin^2 \left[x(t - \tau_D) + \gamma v(t) I(t) + \phi_0 \right], \tag{1}$$

where total delay time is denoted by τ_D.

This model can be used to simulate the reservoir which can help in finding appropriate set of parameters for further experiments.

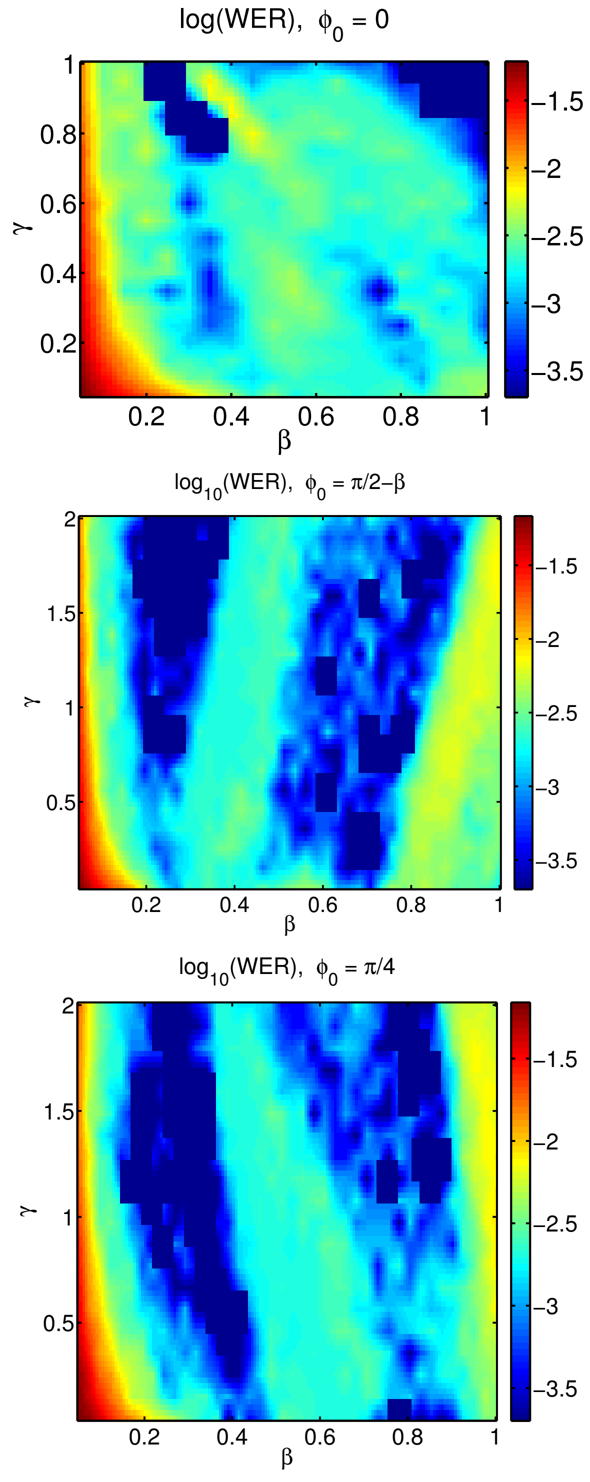
The part of the code which simulate reservoir behavior is shown below.

```
neurwidth=0.2;
%T=nrofneurons*neurwidth;
beta=0.7;
gamma=0.5;
Phi0=pi/4;

%% Input
inkr=5;
binwidth=maskbinwidth*inkr;
h=neurwidth/binwidth;
in=extend(in,binwidth);
in_trans=[zeros(1,floor(500/h)) in];
nsteps=length(in_trans)+nrofneurons*binwidth;
h=neurwidth/binwidth;

%% RC iterations
x=zeros(1,nsteps);
y=zeros(1,nsteps);

% History
x(1:nrofneurons*binwidth)=beta*sin(Phi0)^2*ones(1,nrofneurons*binwidth);

for i=nrofneurons*binwidth:nsteps-1,
    xd=x(i-nrofneurons*binwidth+1)+gamma*in_trans(i-nrofneurons*binwidth+1)+Phi0;
    x(i+1)=x(i)+h*(-x(i)+beta.*sin(xd).^2);
    y(i)=xd;
end

xout=x(end-length(in)+1:inkr:end); %-x(end-length(in));
```

The simulation uses the simple Euler integration method to produce time-trace of reservoir response on input signal. After that the time-trace is down-sampled and cut on equal to number of nodes pieces and stacked in reservoir state matrix. This matrix is used for cross-validation.

2 Simulation

The result of systematic simulations with different parameters are shown in Fig. 1. The WER values is presented in logarithmic scale. The Fig.1 b) is calculated when the relation $\phi_0 = \pi/2 - \beta$ is hold. This relation guarantees that slope at stable point is equal to zero. It is clear seen that areas with small word error rates (or even with 0) occupy quite big range of parameters. It gives good opportunities to find these areas in real experiments (this fact is proven by experiments in Palma and our experiment but with a bit different setup incorporating multiple delays).



a)

b)

c)

Fig. 1: WER values for various parameters sets