
Elastic Region of Attraction Example

Table of Contents

Define the State Space Model	1
Region of Attraction (Lyapunov)	1
Elastic Region of Attraction	2
Elastic Region of Attraction (Radial)	3

An example of estimating the region of attraction of the Van der Pol equation in reverse time using an elastic search method.

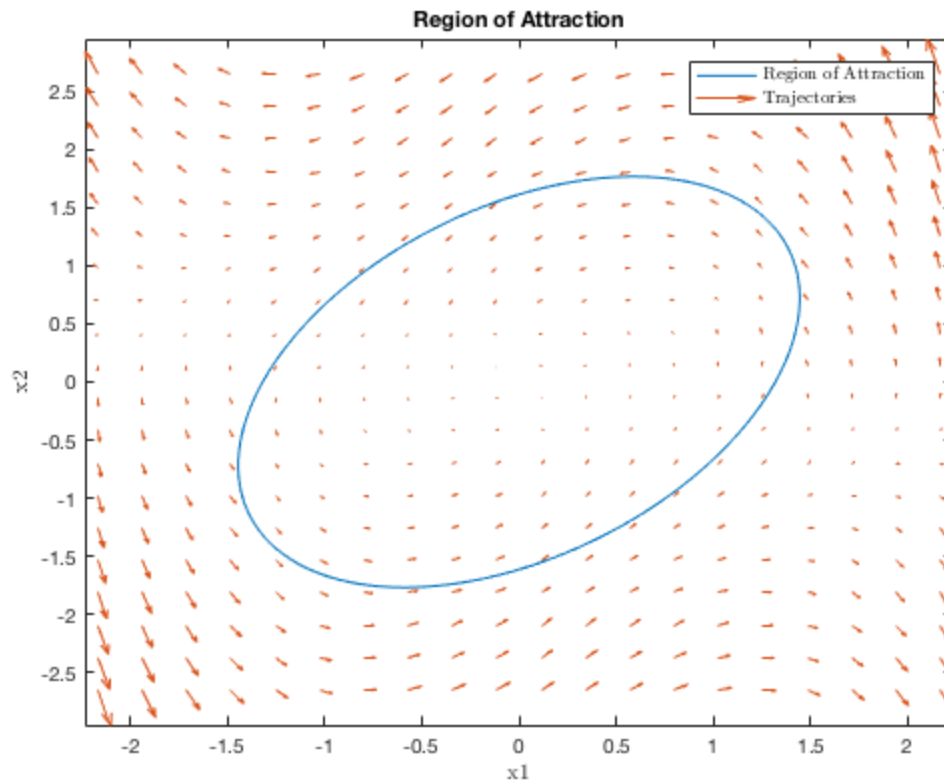
Define the State Space Model

```
syms x1 x2
sys = symss;
sys.states = [x1 x2];
sys.f(1) = -x2;
sys.f(2) = x1 + (x1^2 - 1)*x2;
```

Region of Attraction (Lyapunov)

The standard method for determining the region of attraction uses the Lyapunov method, and generally gives a conservative result.

```
roa(sys);
```



We can see that the default Lyapunov boundary produces a poor estimation of the region of attraction. In order to produce a better approximation, we can use an elastic search method.

Elastic Region of Attraction

Compute the elastic region of attraction using the standard method.

```
R = elasticroa(sys, 'Points', 30, 'Radial', false);
```

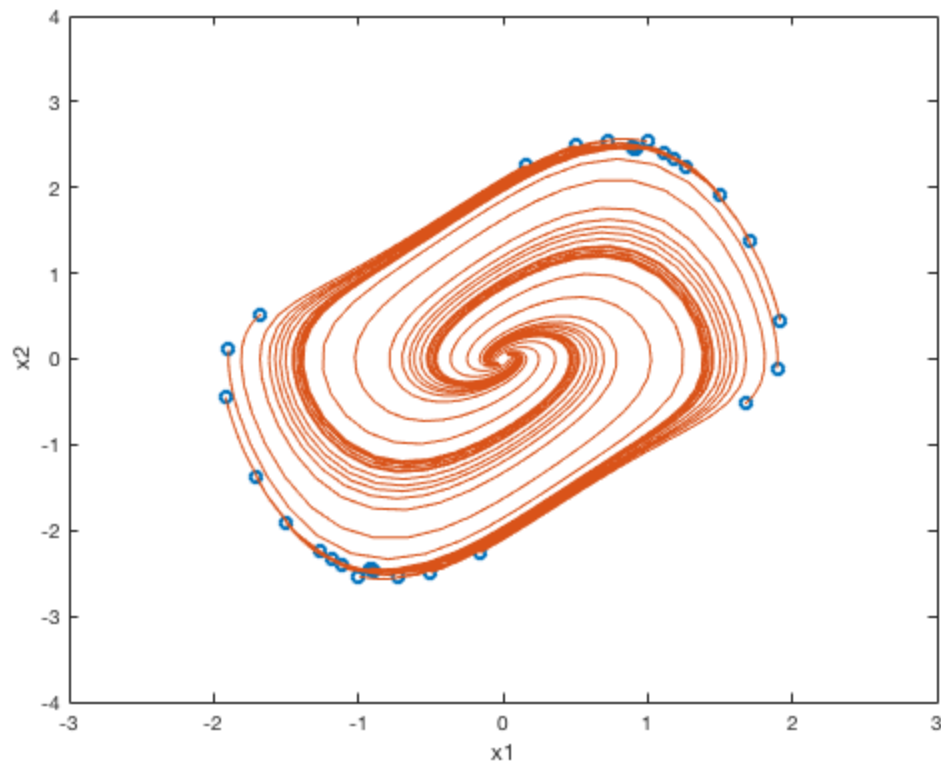
Convert the points to initial conditions.

```
ic = num2cell(R, 2);
```

Plot the trajectories using the initial conditions.

```
tspan = [0 10];
```

```
plot(R(:, 1), R(:, 2), 'o')  
hold on  
nlsim2(sys, tspan, ic)  
hold off  
xlim([-3 3])  
ylim([-4 4])
```



We can see from the plot that the elastic method provides a less conservative region of attraction than the Lyapunov method. However, the points on the ring are drawn to the extrema of the region of attraction and can miss some non-convex boundaries.

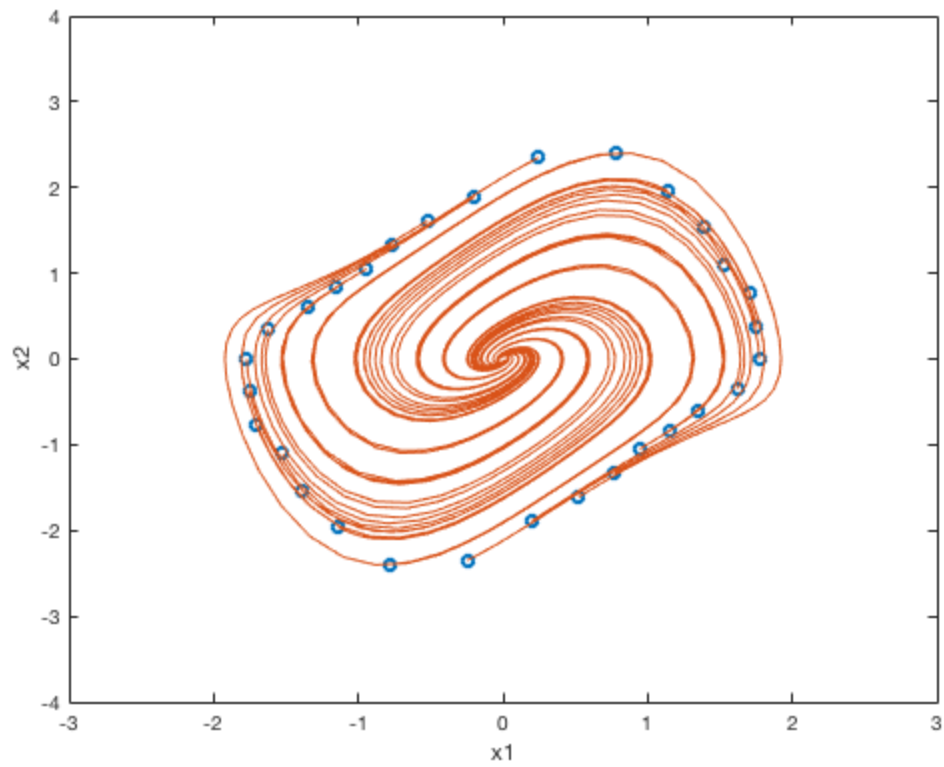
Elastic Region of Attraction (Radial)

Compute the elastic region of attraction using the radial method.

```
R = elasticroa(sys, 'Points', 30, 'Radial', true);  
ic = num2cell(R, 2);
```

Plot the trajectories using the initial conditions.

```
plot(R(:, 1), R(:, 2), 'o')  
hold on  
nlsim2(sys, tspan, ic)  
hold off  
xlim([-3 3])  
ylim([-4 4])
```



The radial method in general produces a more conservative result than the standard method. However, we can see that because the points are restricted to only moving radially outward, we can detect non-convex regions with greater accuracy than the standard method.

Published with MATLAB® R2017b