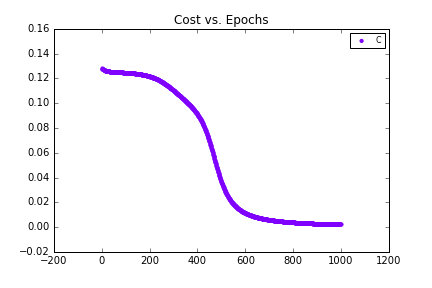
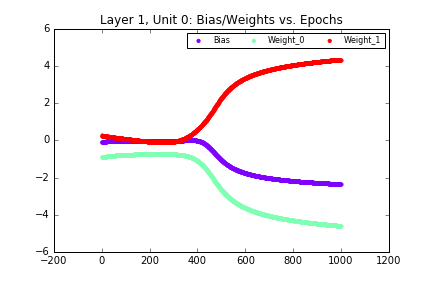
Adam Gross and Josh Palmer

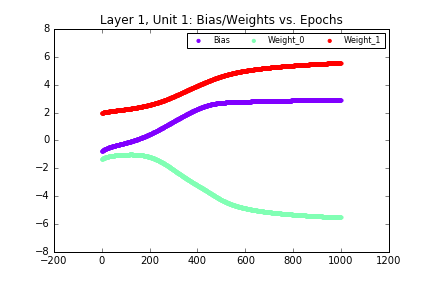
Assignment 5 Write-up

1. Tests on the XOR problem with one hidden layer with two units

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Hidden layer units’ bias and weights changes:

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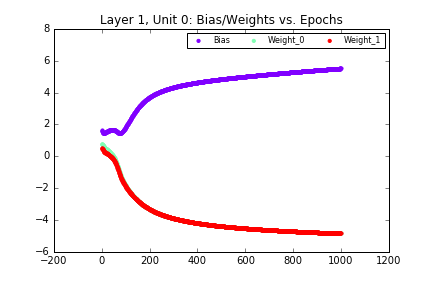
1. The table below shows the final costs for the different topologies we tested. Our minimal cost for a single hidden layer topology was with 4 hidden layer units, and for a double hidden layer topology it was with 2 units in each layer:

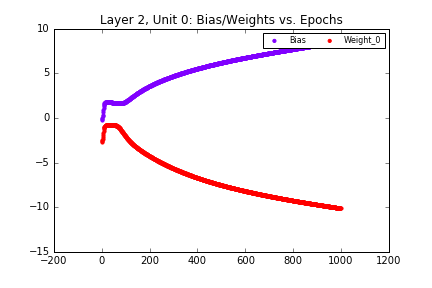
|  |  |
| --- | --- |
| **Topology** | **Final Cost** |
| [2, 1, 4] | 0.12957 |
| [2, 2, 4] | 0.00322 |
| [2, 3, 4] | 0.00302 |
| [2, 4, 4] | 0.00265 |
| [2, 1, 1, 4] | 0.13444 |
| [2, 1, 2, 4] | 0.11083 |
| [2, 1, 3, 4] | 0.00694 |
| [2, 1, 4, 4] | 0.00387 |
| [2, 2, 1, 4] | 0.13343 |
| [2, 2, 2, 4] | 0.00326 |
| [2, 2, 3, 4] | 0.00373 |
| [2, 2, 4, 4] | 0.00199 |
| [2, 3, 1, 4] | 0.12998 |
| [2, 3, 2, 4] | 0.00367 |
| [2, 3, 3, 4] | 0.00255 |
| [2, 3, 4, 4] | 0.00355 |
| [2, 4, 1, 4] | 0.12590 |
| [2, 4, 2, 4] | 0.00436 |
| [2, 4, 3, 4] | 0.00242 |
| [2, 4, 4, 4] | 0.00225 |

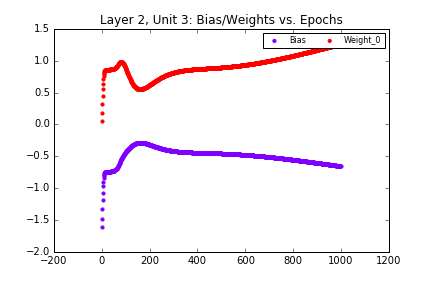
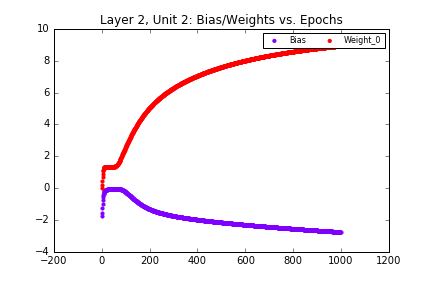
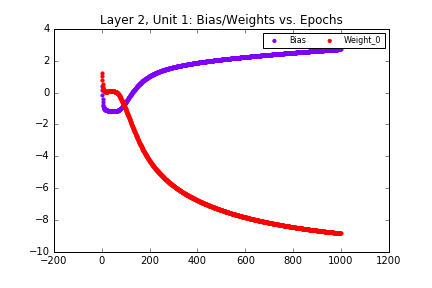
From inspecting the weights’ learning over time, our intuitive sense is that the hidden units are calculating XXXXXXXXXXX because YYYYYYYYYYYYY.

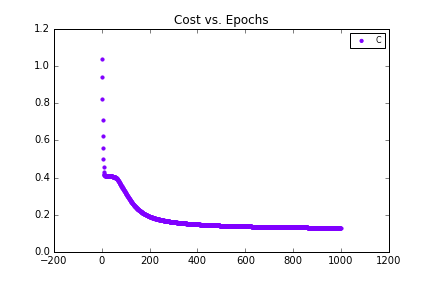
Plots of our different parameters tested are provided on the remaining pages. We had two input values and four outputs representing OR, AND, NAND, and XOR. The variables were the number of hidden layers and the number of units in those hidden layers. We performed tests with all combinations of 1, or 2 hidden layers and 1, 2, 3, or 4 hidden layer units.

**2 inputs, 1 hidden layer unit, 4 outputs**

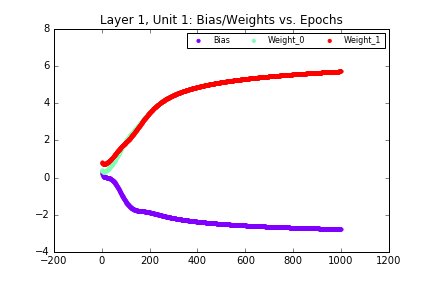
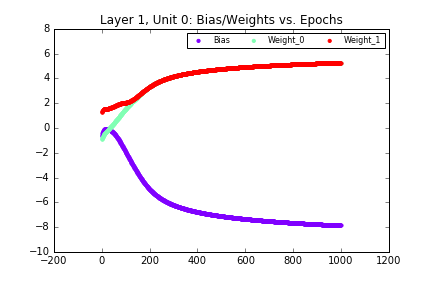
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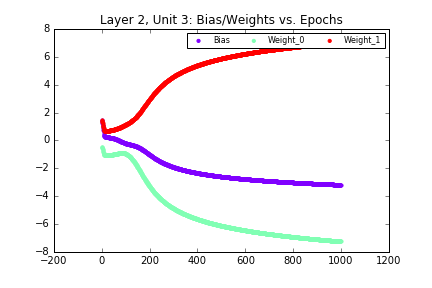
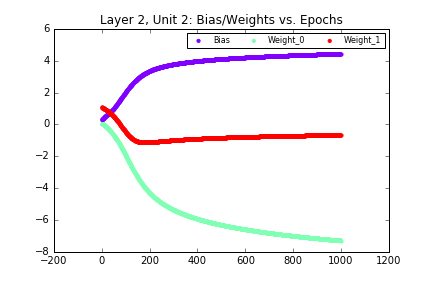
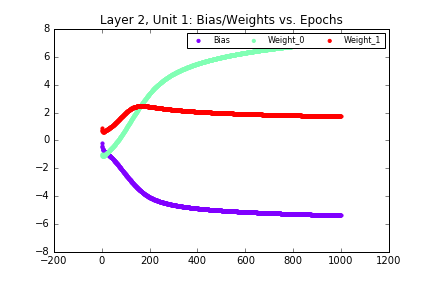
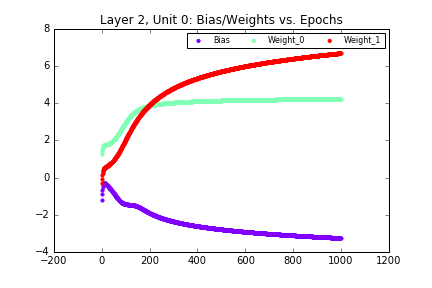
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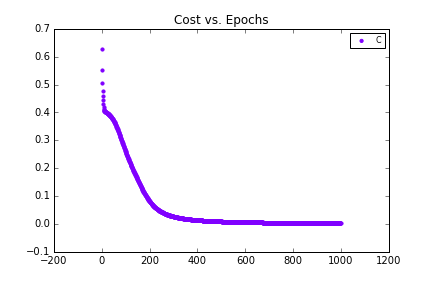
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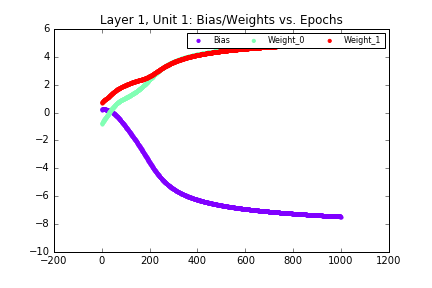
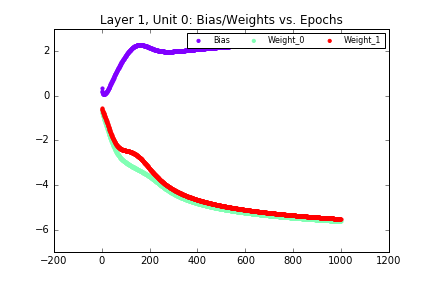
**2 inputs, 2 hidden layer units, 4 outputs**

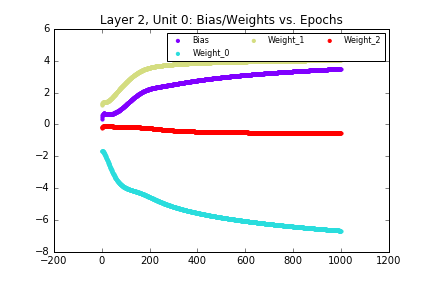
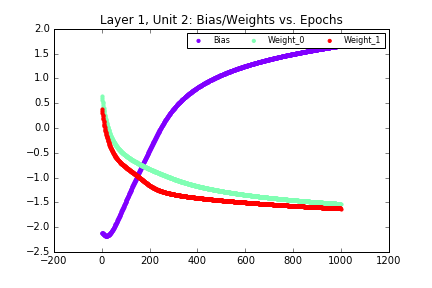
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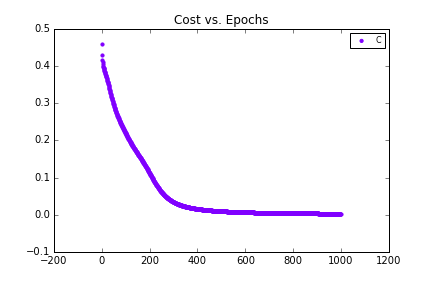
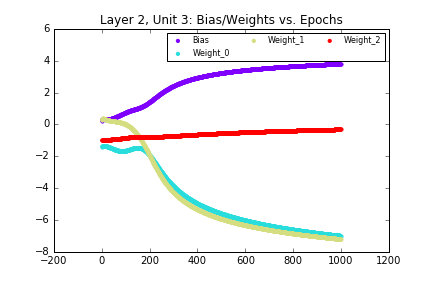
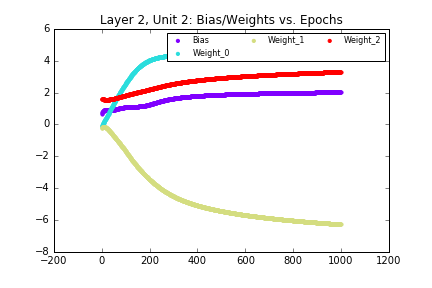
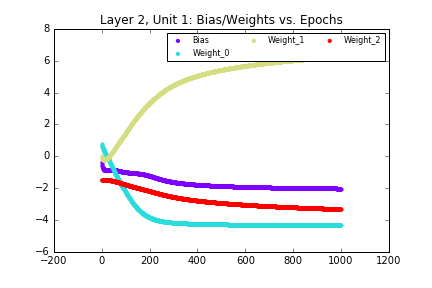
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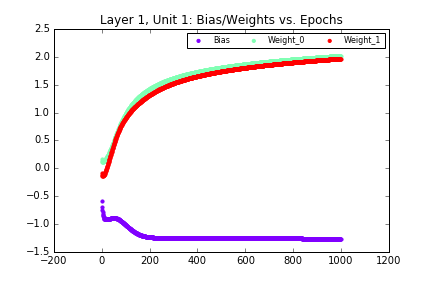
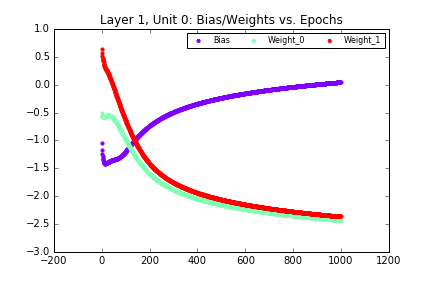
**2 inputs, 3 hidden layer units, 4 outputs**

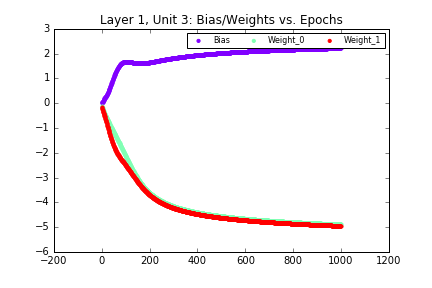
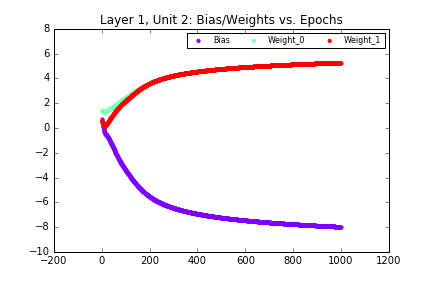
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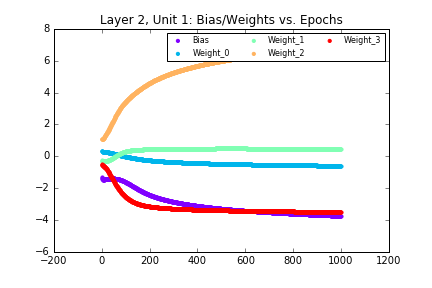
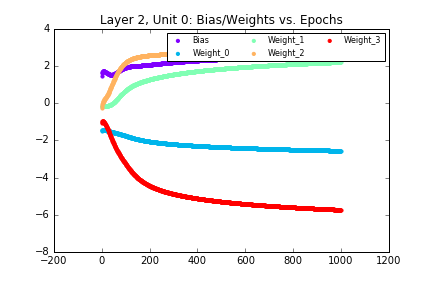
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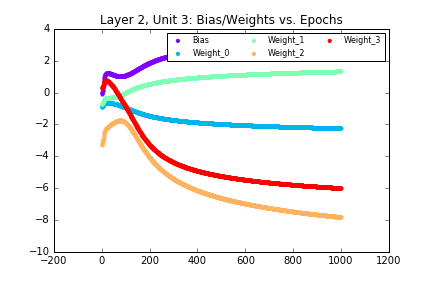
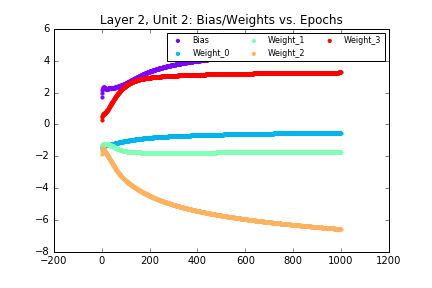
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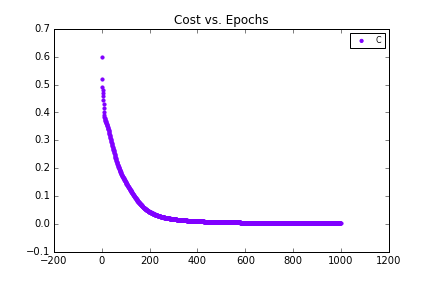
**2 inputs, 4 hidden layer units, 4 outputs**

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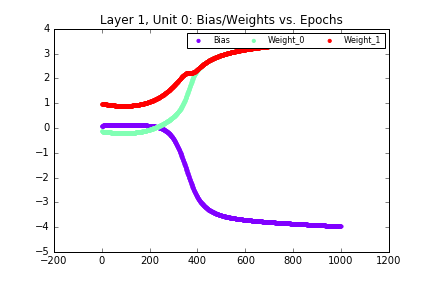
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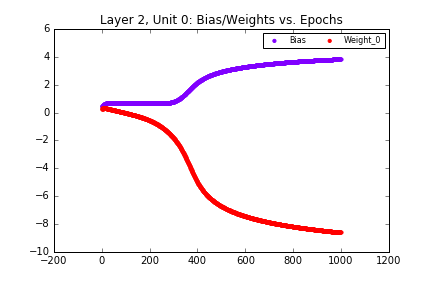
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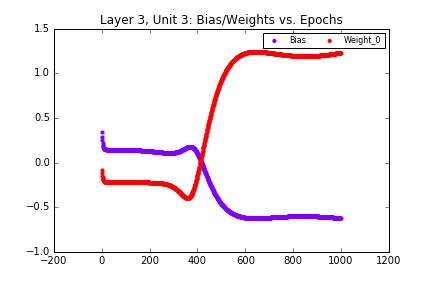
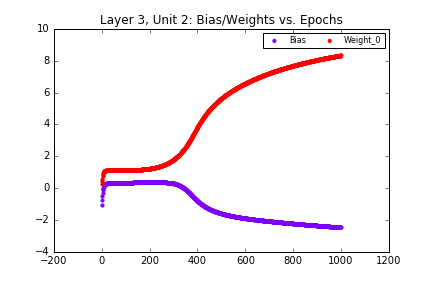
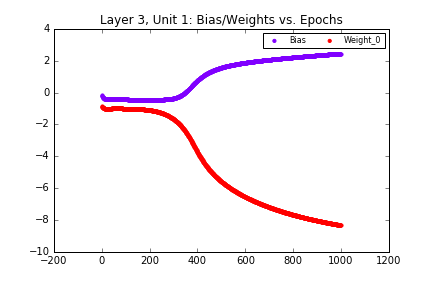
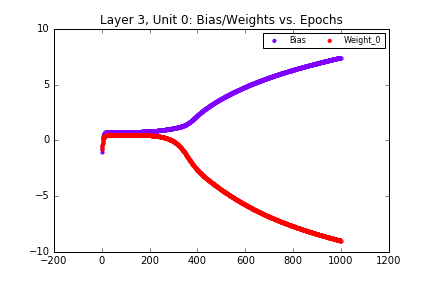
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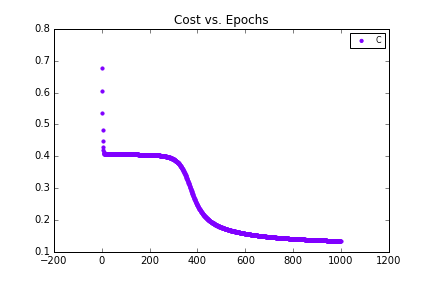
****

**2 inputs, 2 hidden layers each of size 1, four outputs**

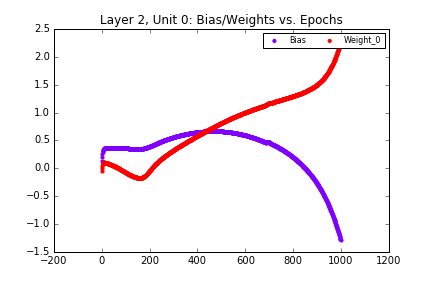
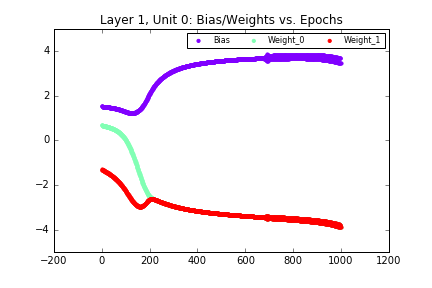
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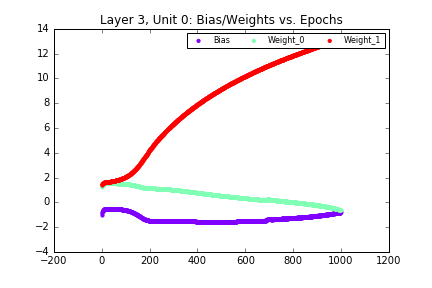
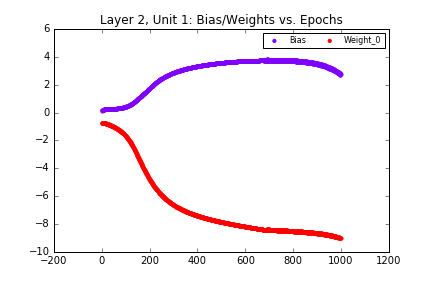
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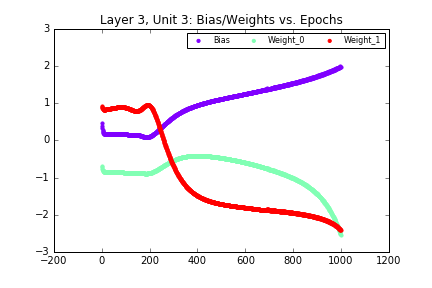
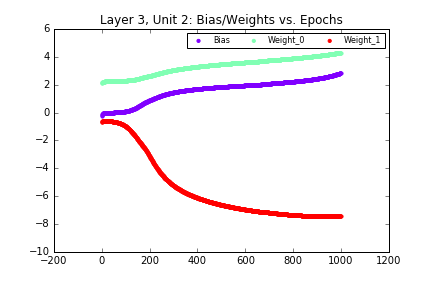
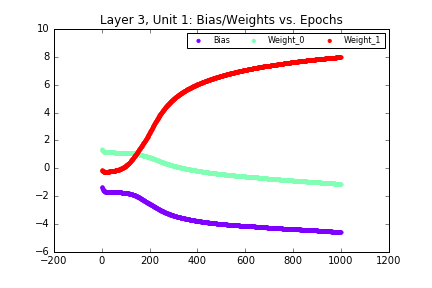
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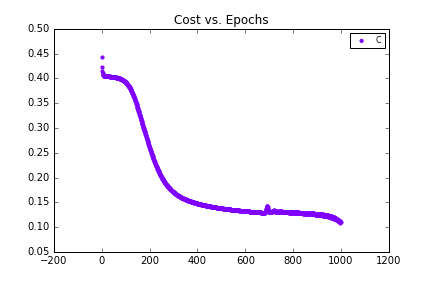
****

**2 inputs, 2 hidden layers, first of size one, second of size 2, four outputs**

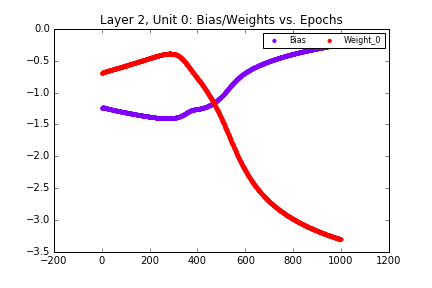
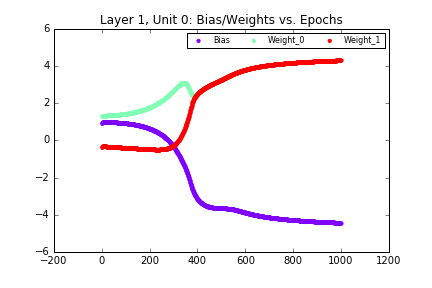
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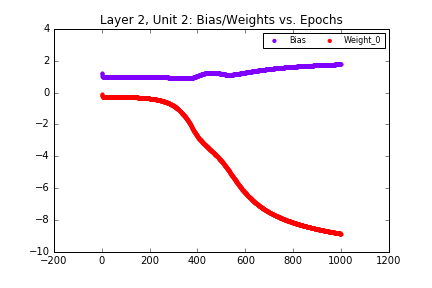
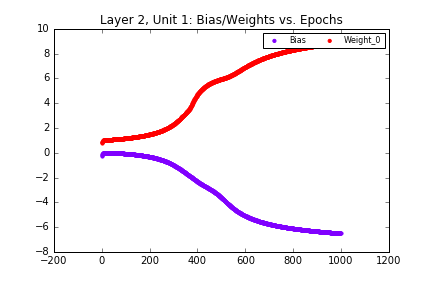
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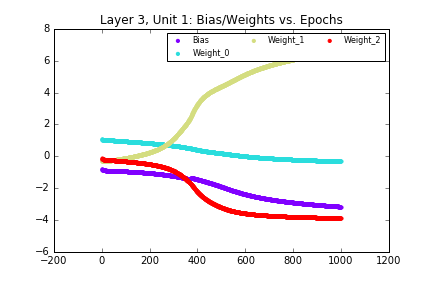
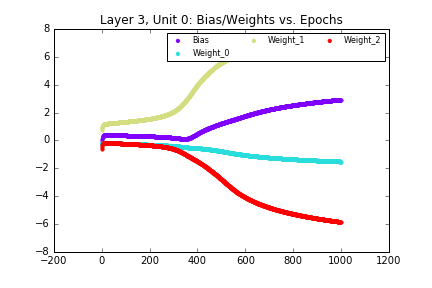
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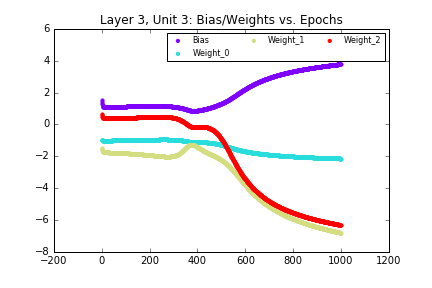
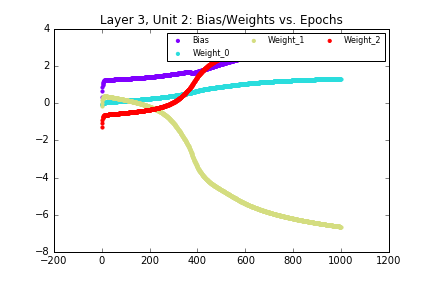
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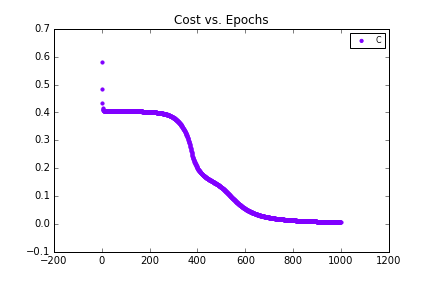
**2 inputs, 2 hidden layers, first of size one, second of size 3, four outputs**

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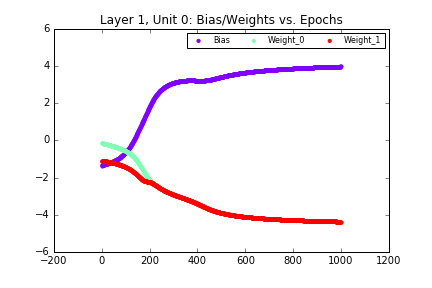
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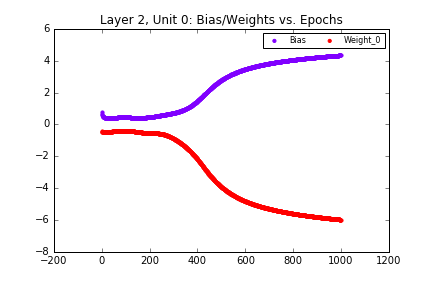
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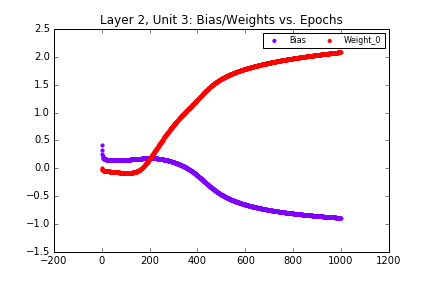
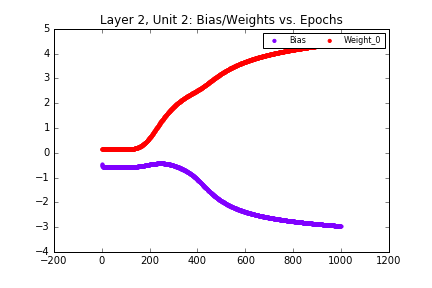
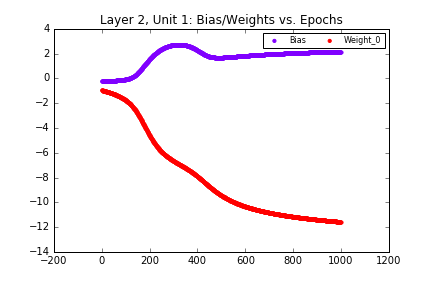
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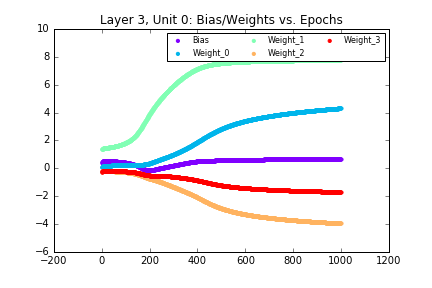
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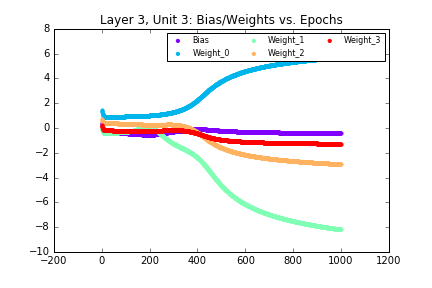
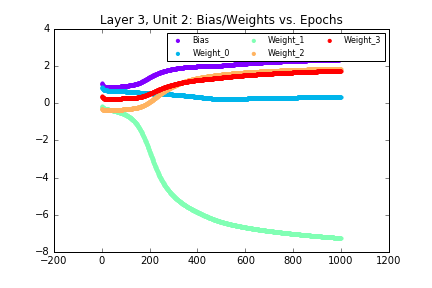
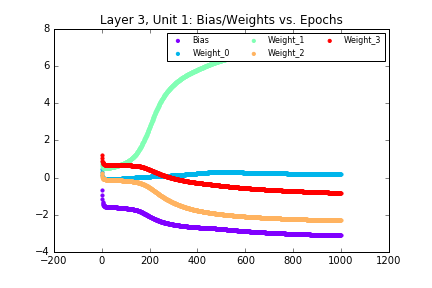
**2 inputs, 2 hidden layers, first of size one, second of size 4, four outputs**

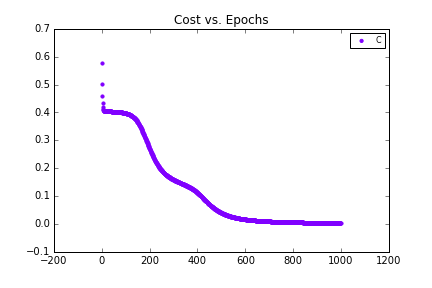
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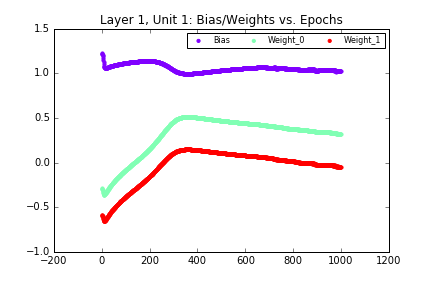
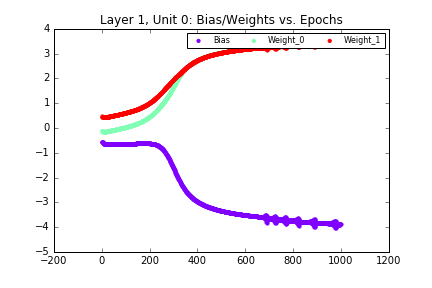
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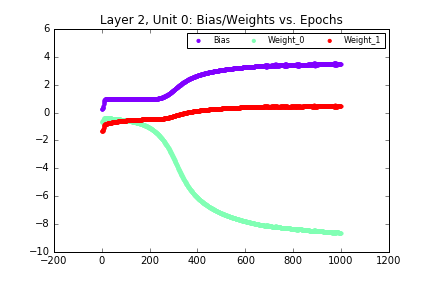
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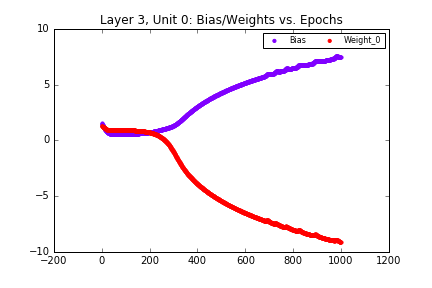
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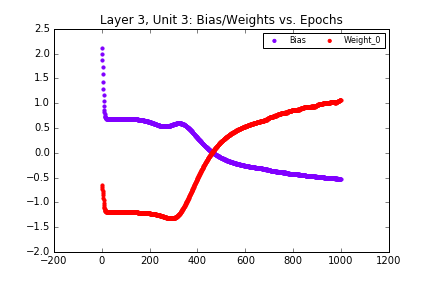
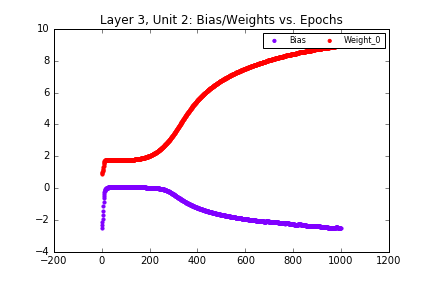
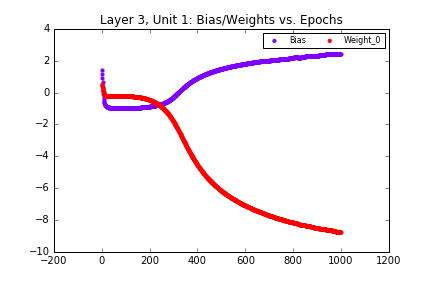
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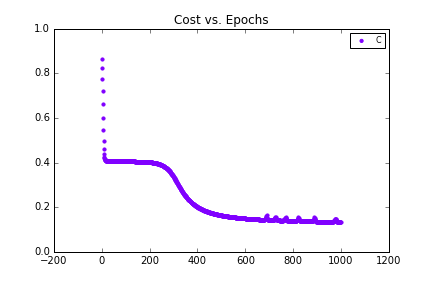
**2 input units, 2 hidden layers, first of size 2 second of size 1, 4 output units**

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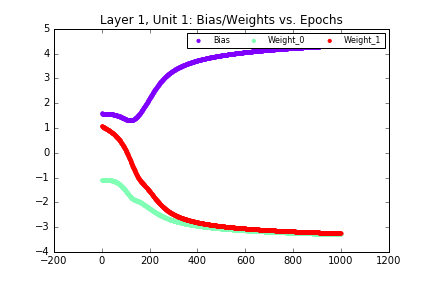
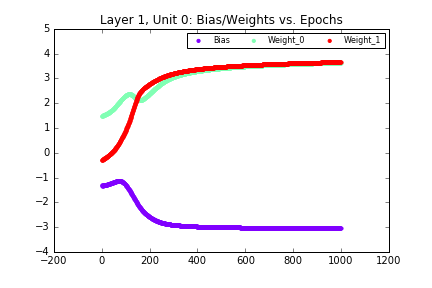
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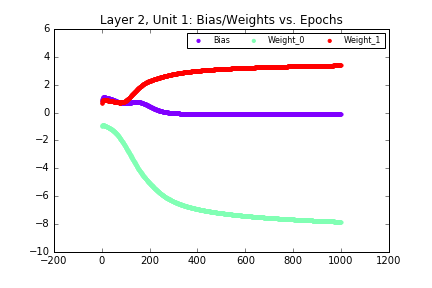
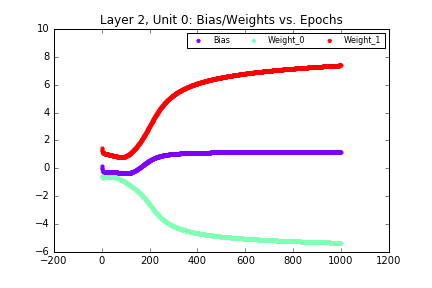
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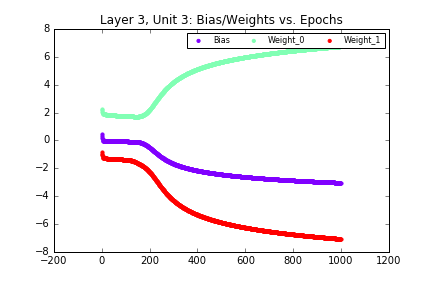
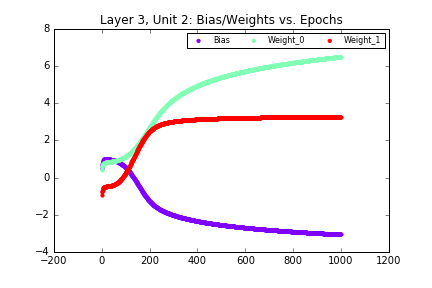
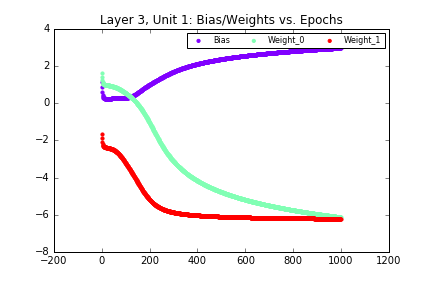
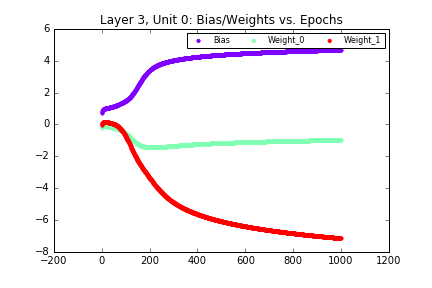
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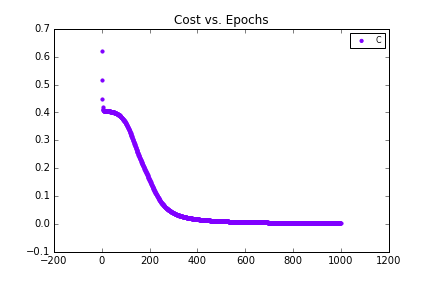
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**2 input units, 2 hidden layers, first of size 2 second of size 2, 4 output units**

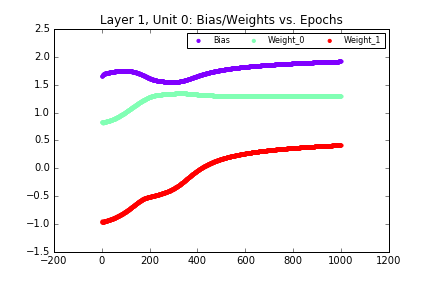
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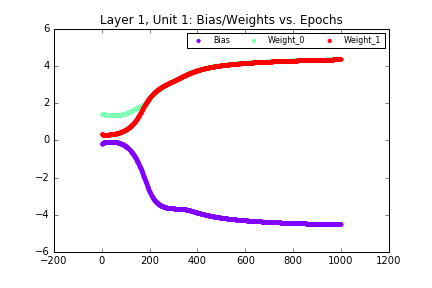
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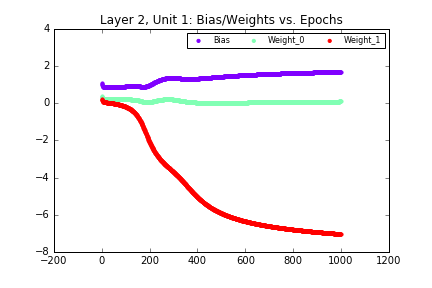
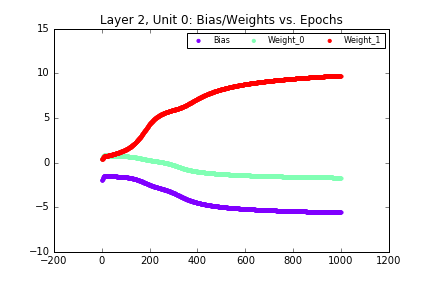
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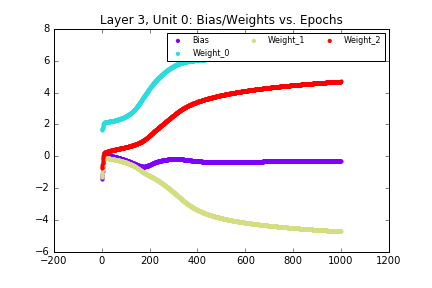
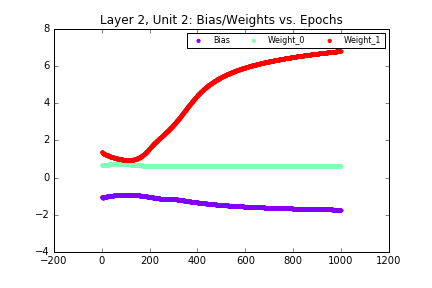
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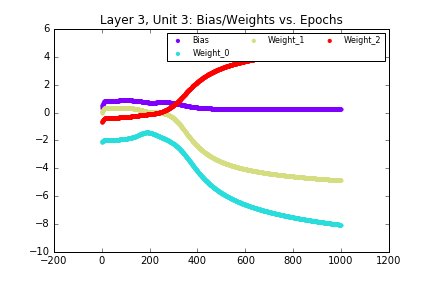
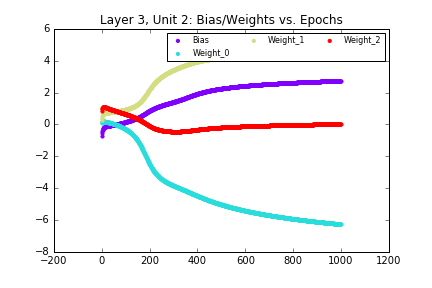
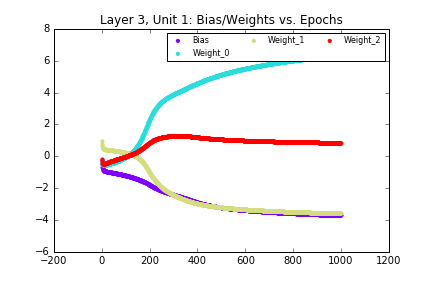
**2 input units, 2 hidden layers, first of size 2 second of size 3, 4 output units**

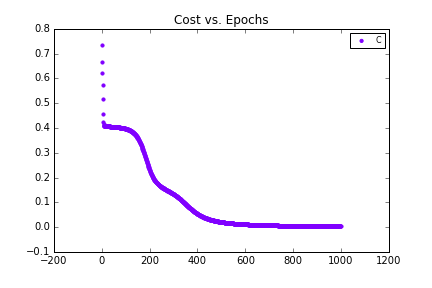
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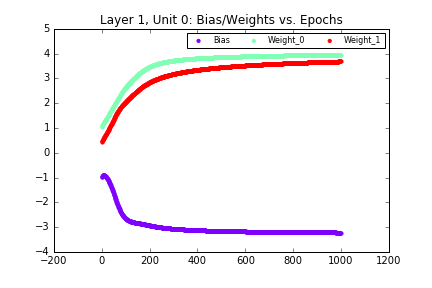
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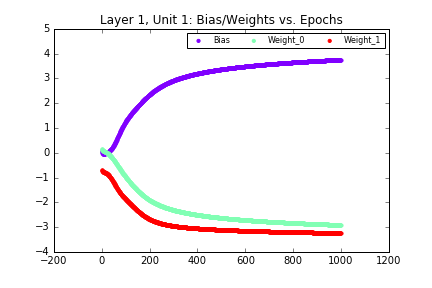
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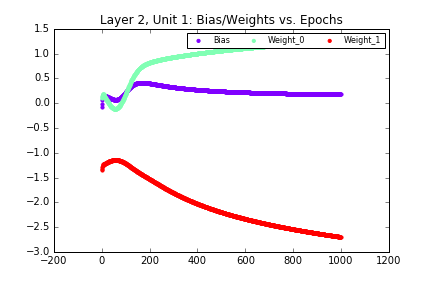
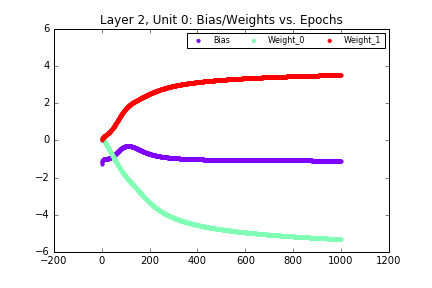
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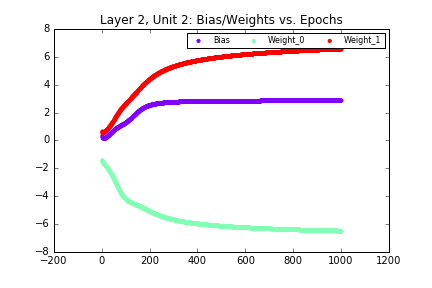
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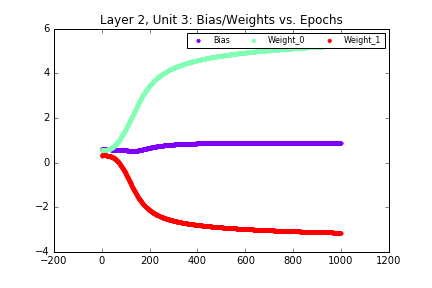
**2 input units, 2 hidden layers, first of size 2 second of size 4, 4 output units**

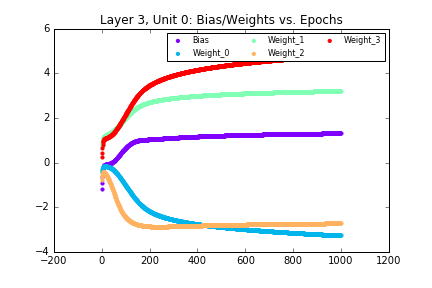
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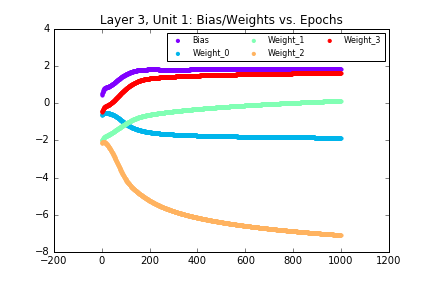
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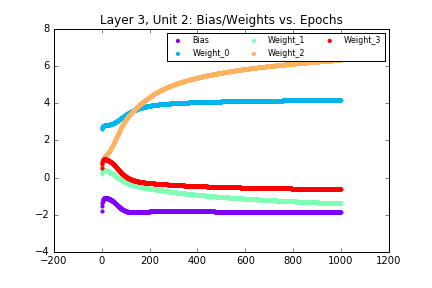
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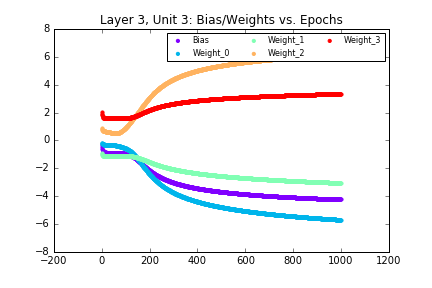
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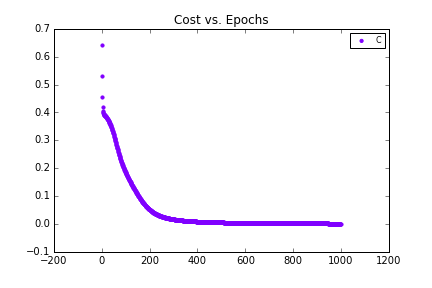
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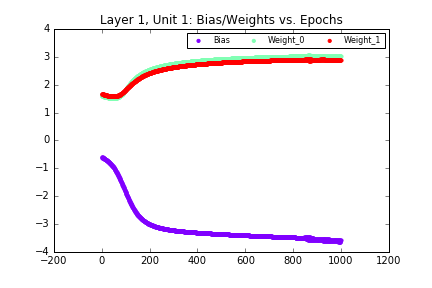
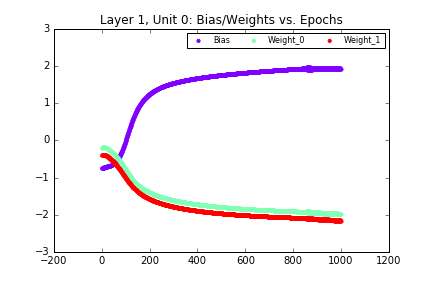
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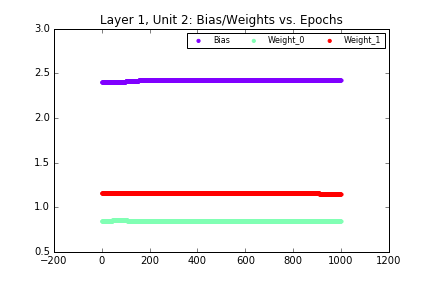
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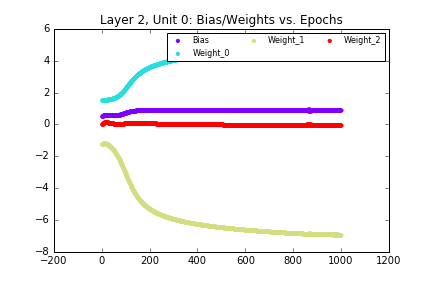
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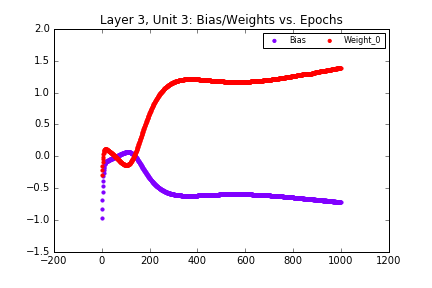
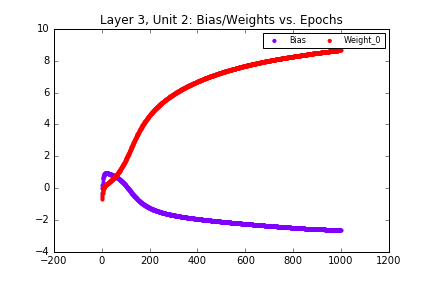
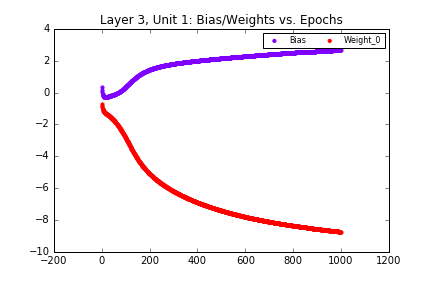
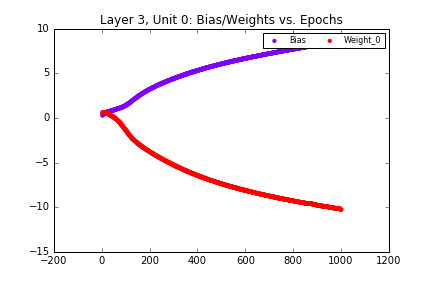
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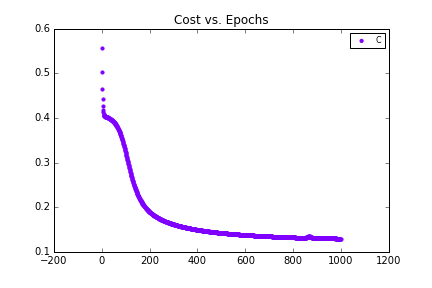
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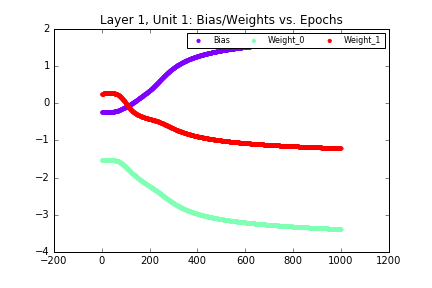
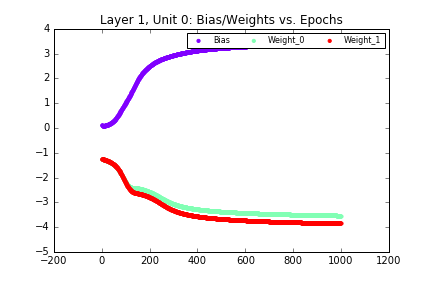
**2 input units, 2 hidden layers, first of size 3, second of size 1, 4 output units**

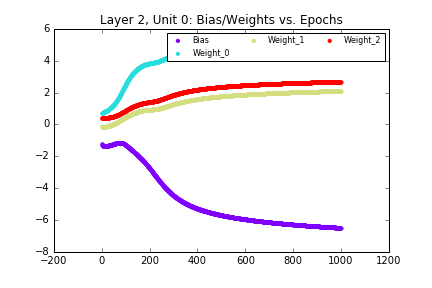
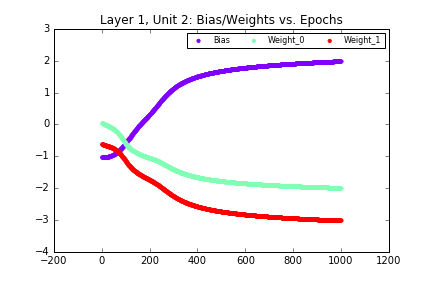
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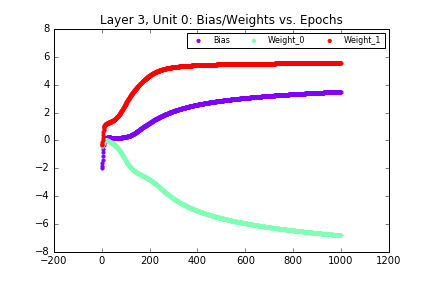
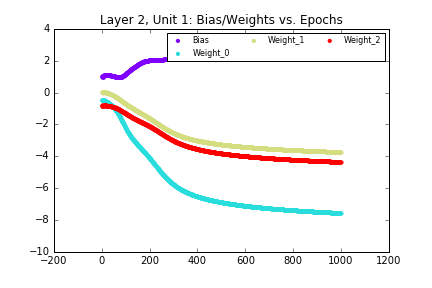
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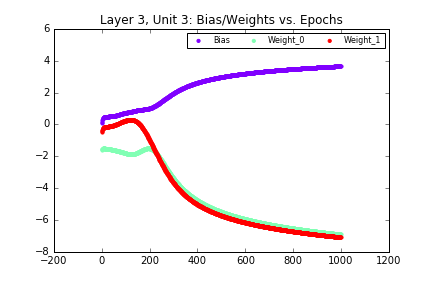
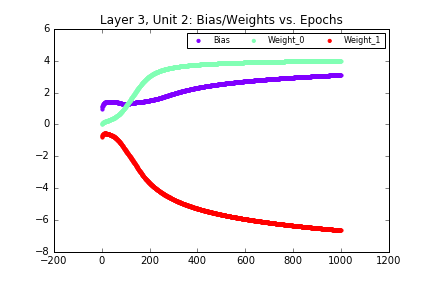
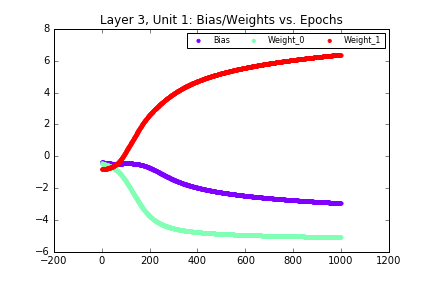
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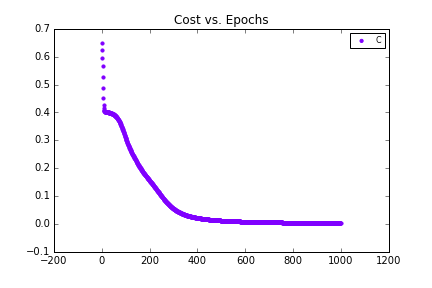
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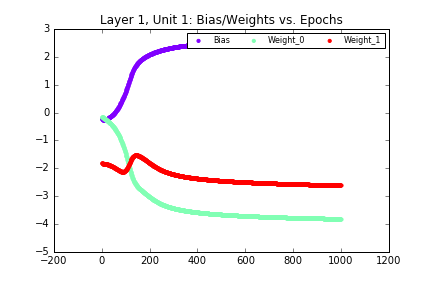
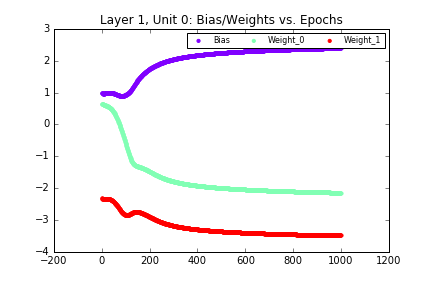
**2 input units, 2 hidden layers, first of size 3, second of size 2, 4 output units**

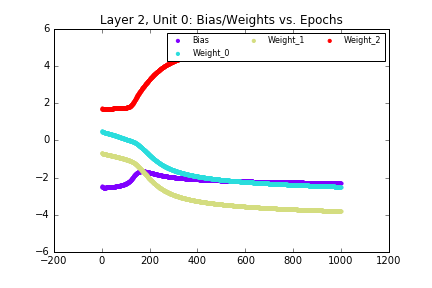
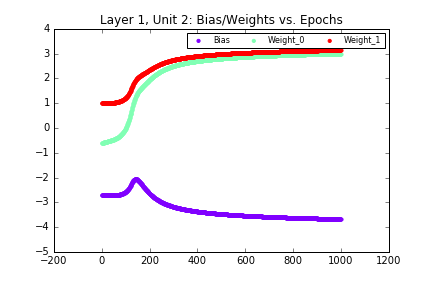
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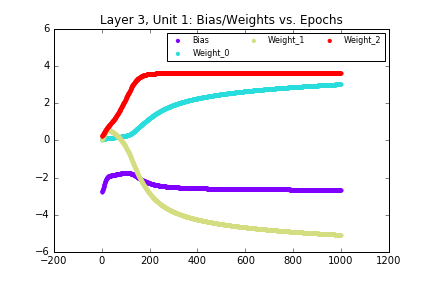
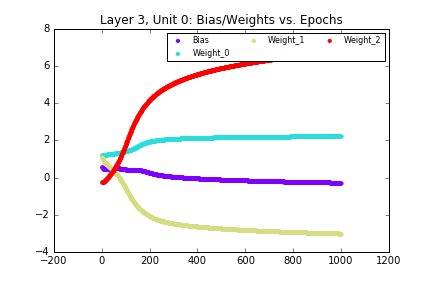
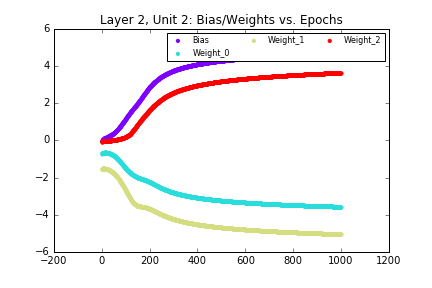
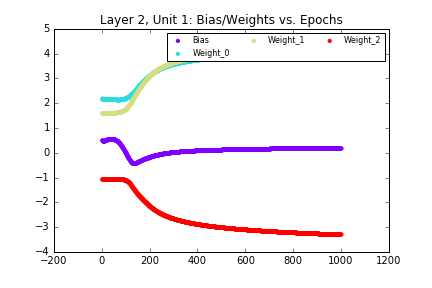
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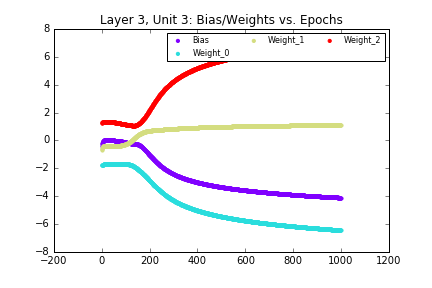
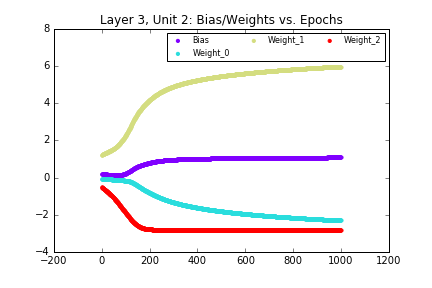
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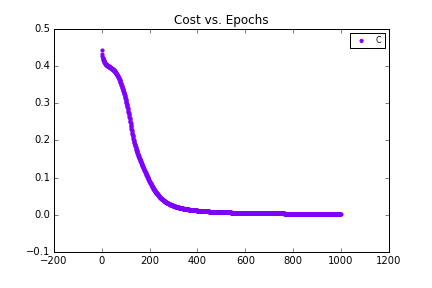
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**2 input units, 2 hidden layers, first of size 3, second of size 3, 4 output units**

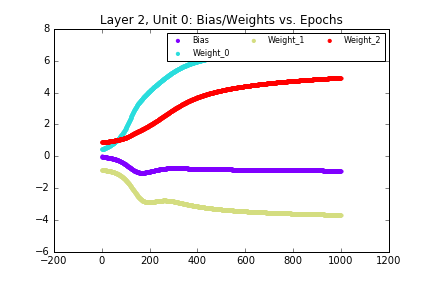
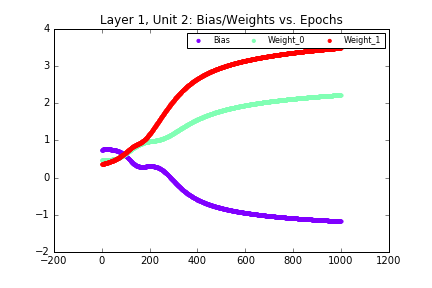
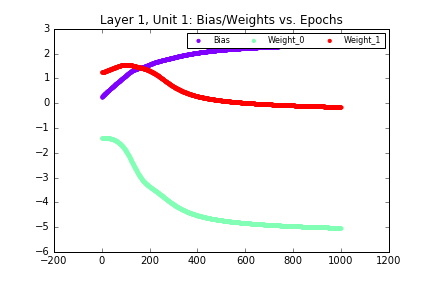
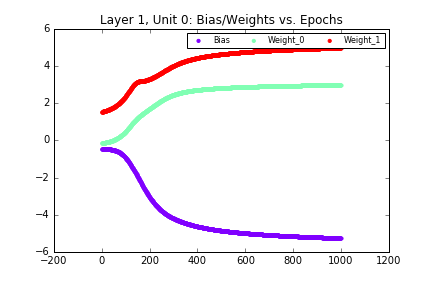
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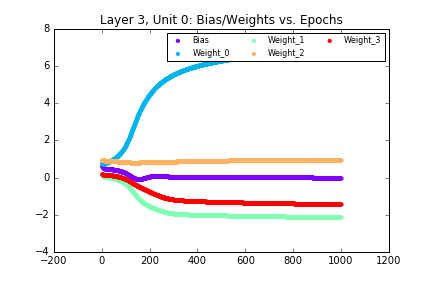
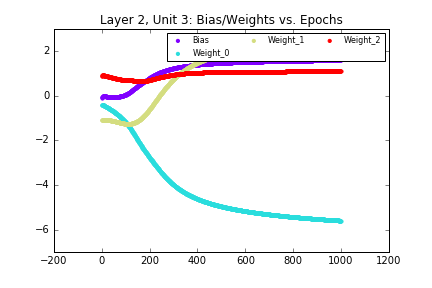
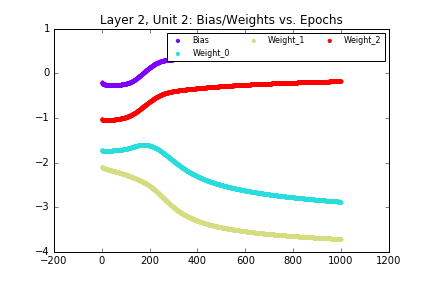
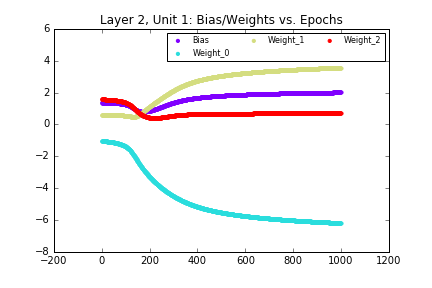
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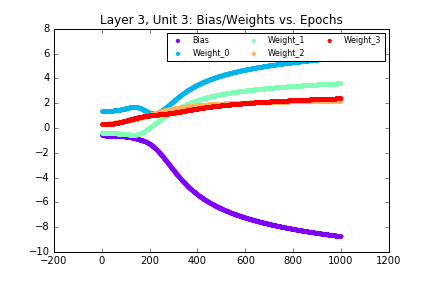
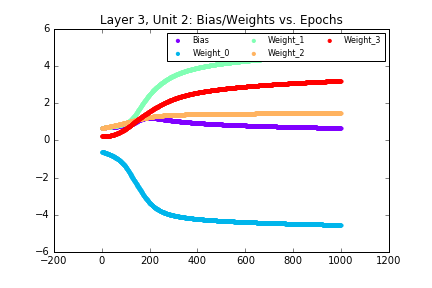
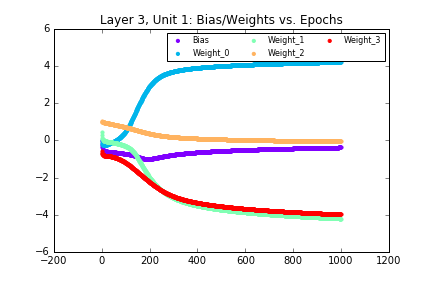
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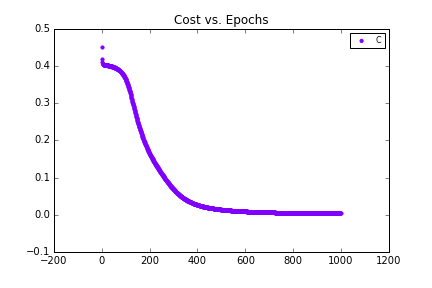
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**2 input units, 2 hidden layers, first of size 3, second of size 4, 4 output units**

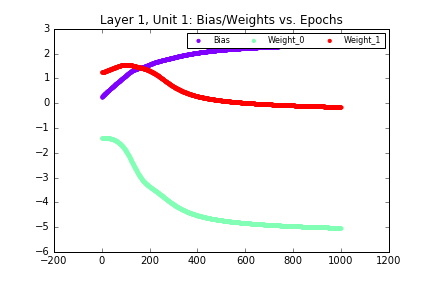
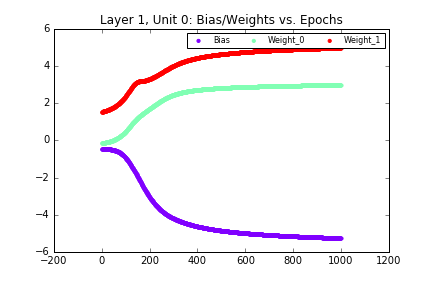
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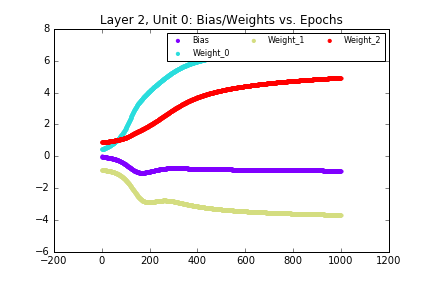
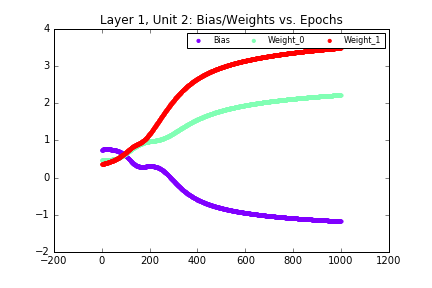
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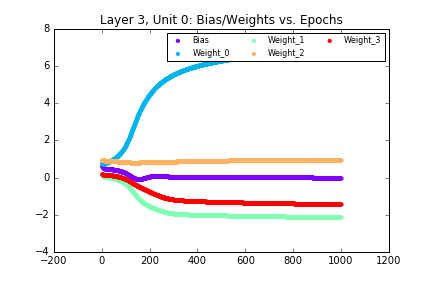
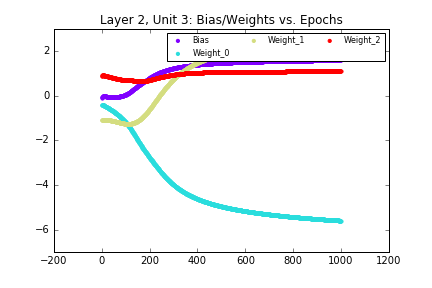
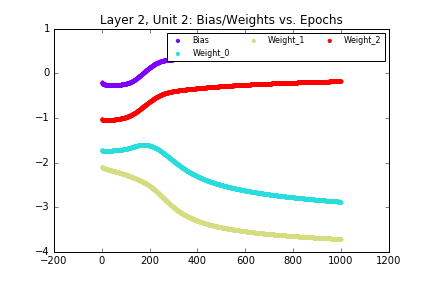
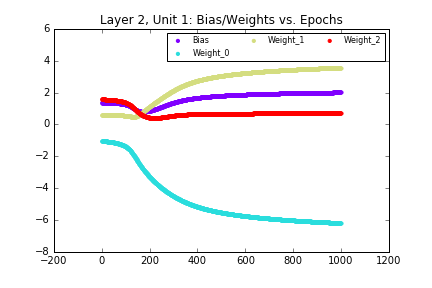
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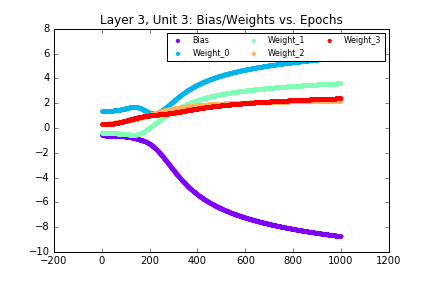
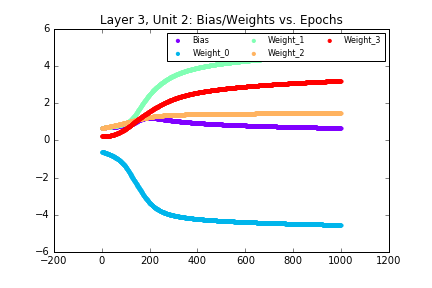
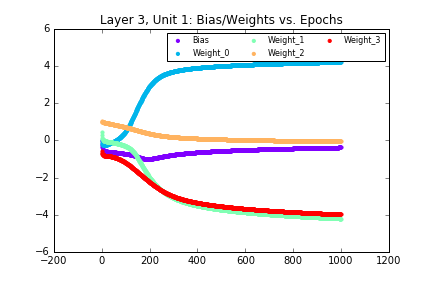
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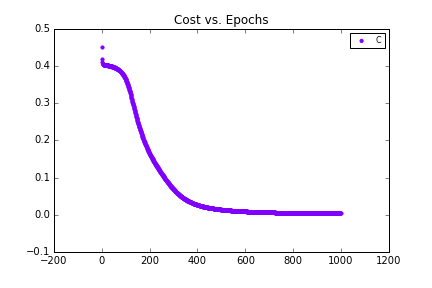
**2 input units, 2 hidden layers, first of size 3, second of size 4, 4 output units**

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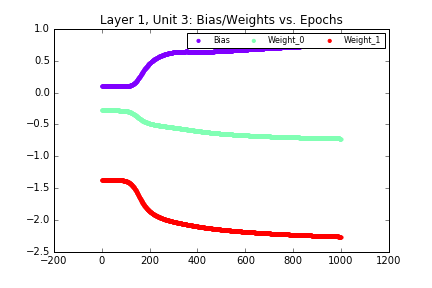
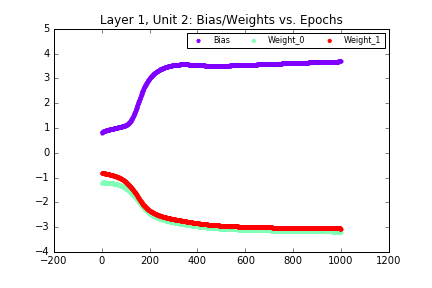
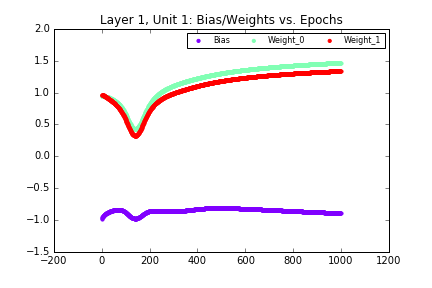
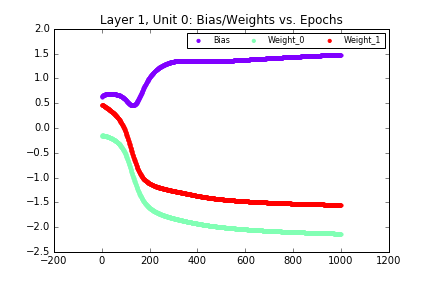
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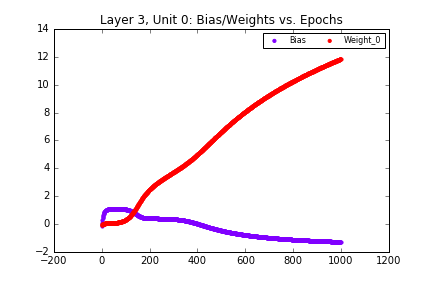
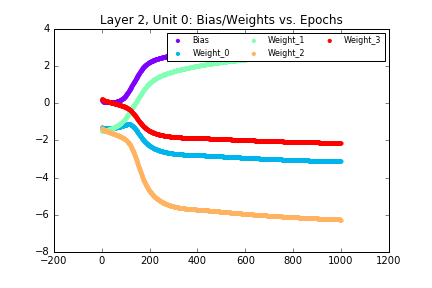
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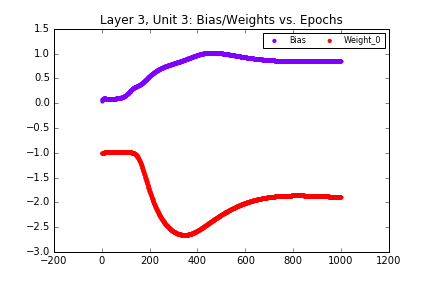
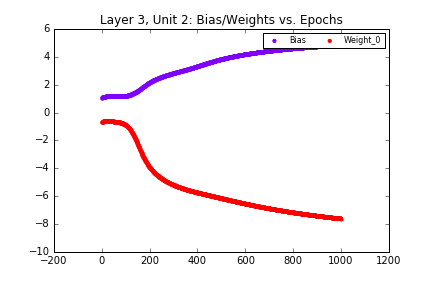
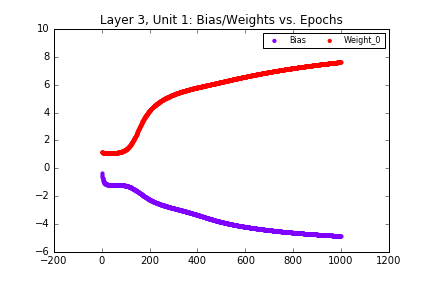
****

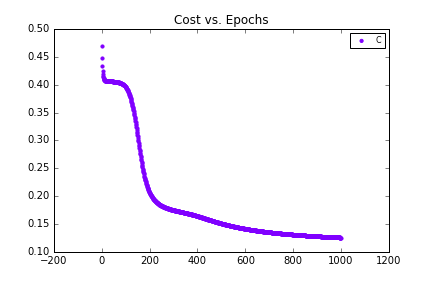
****

**2 inputs, 2 hidden layers, first of size 4, second of size 1, 4 output units**

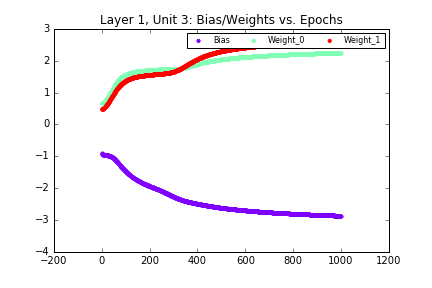
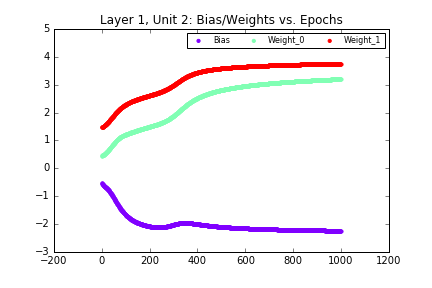
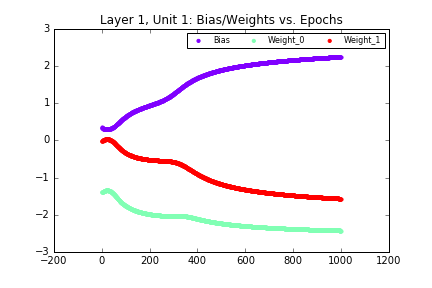
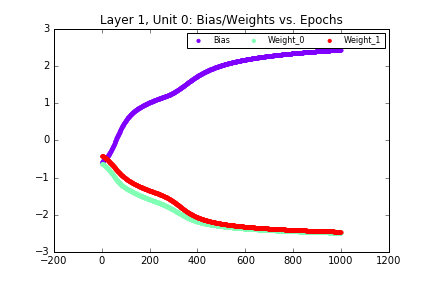
****

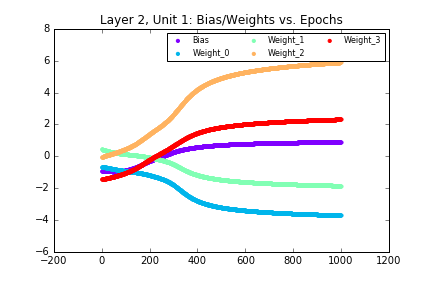
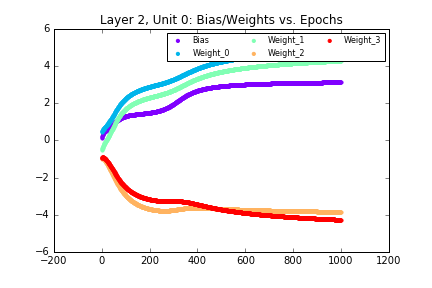
****

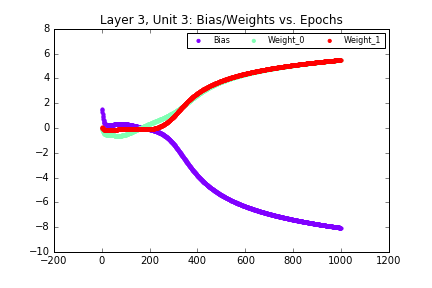
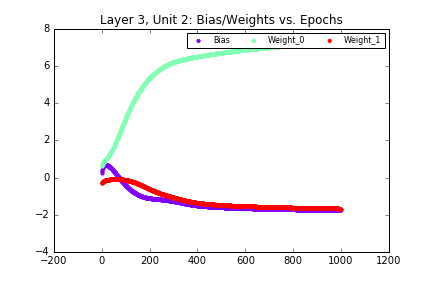
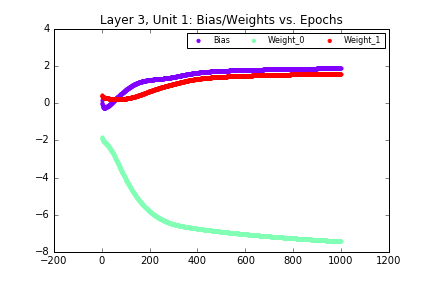
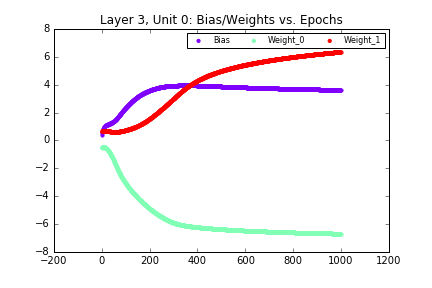
****

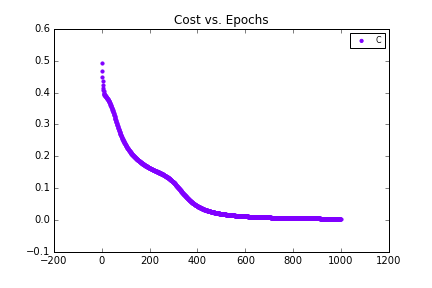
****

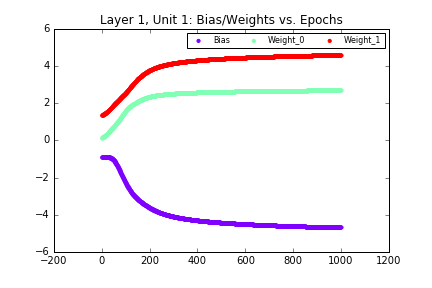
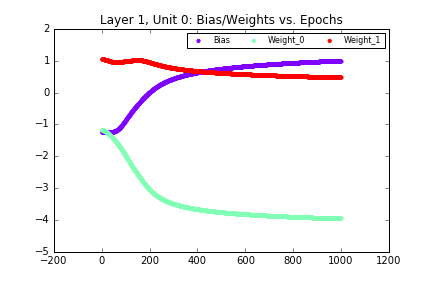
**2 inputs, 2 hidden layers, first of size 4, second of size 2, 4 output units**

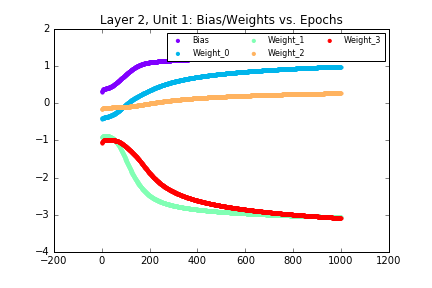
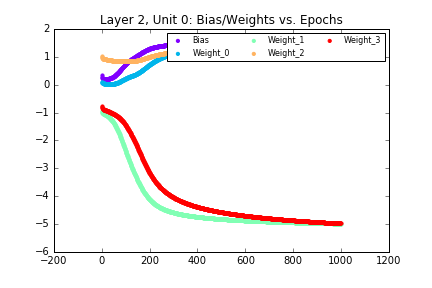
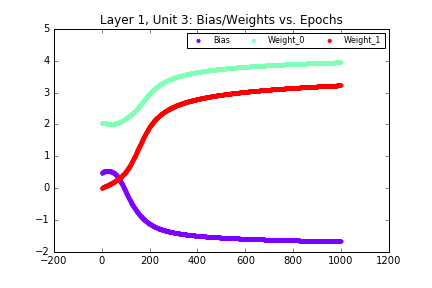
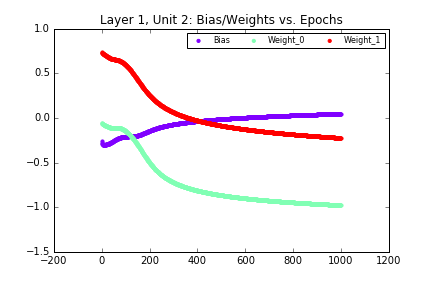
****

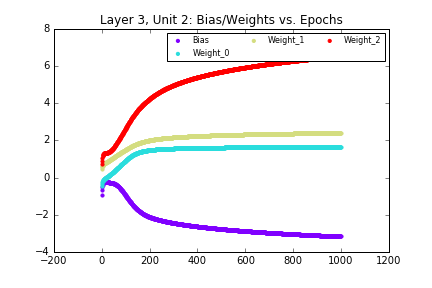
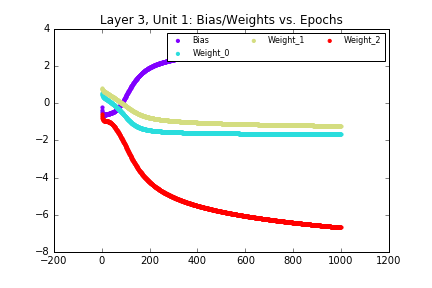
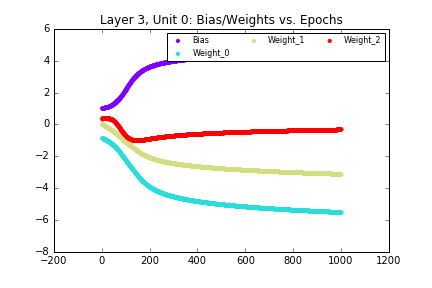
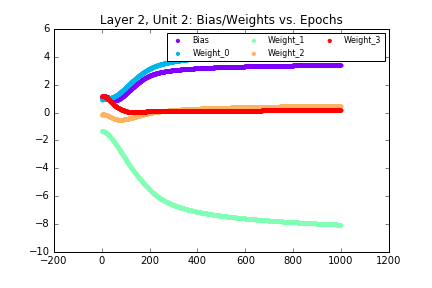
****

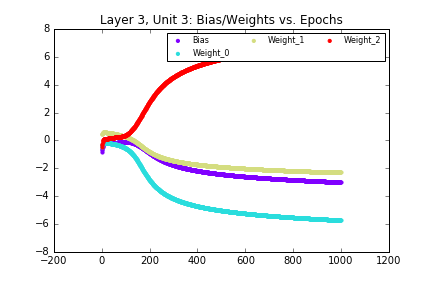
****

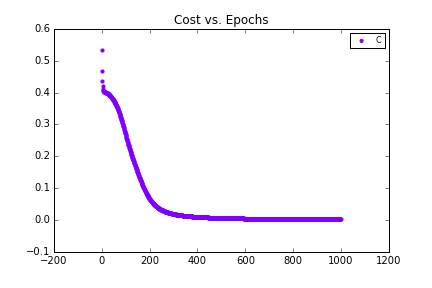
****

**2 inputs, 2 hidden layers, first of size 4, second of size 3, 4 output units**

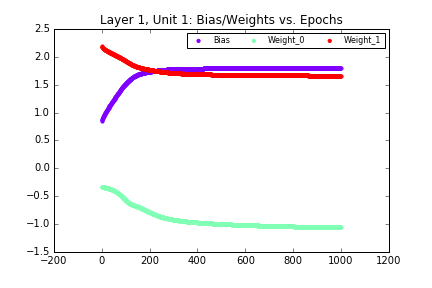
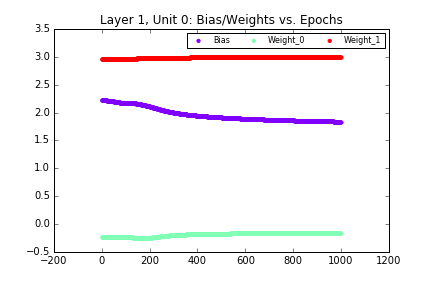
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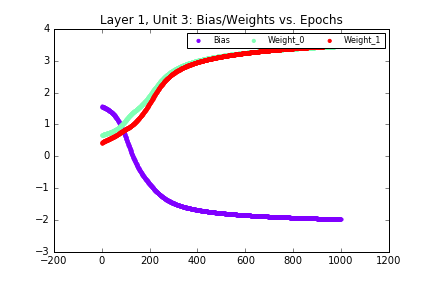
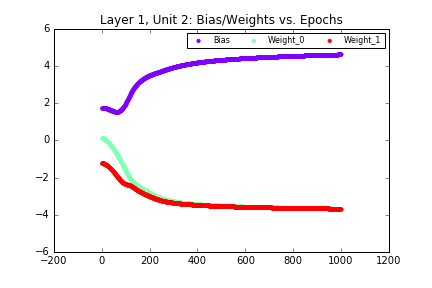
****

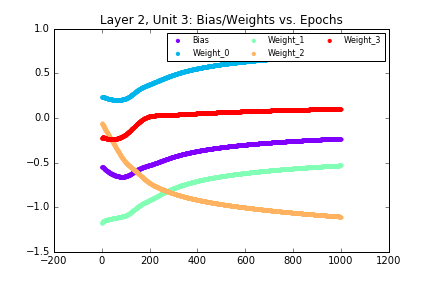
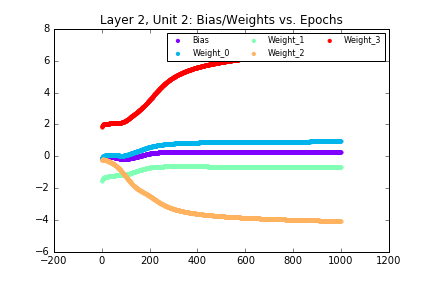
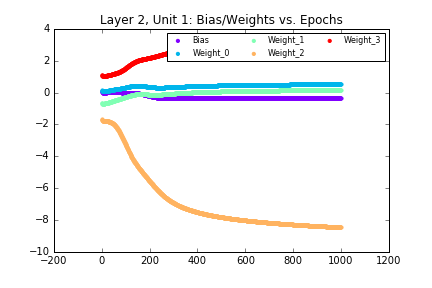
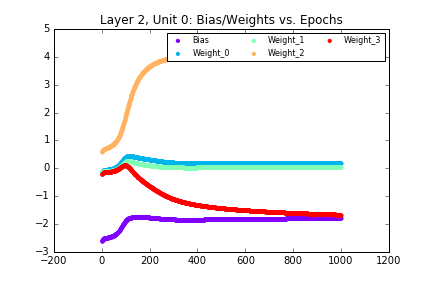
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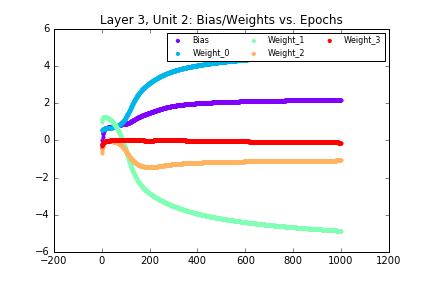
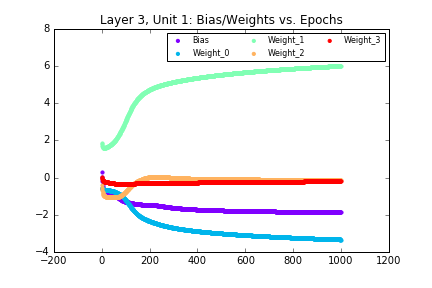
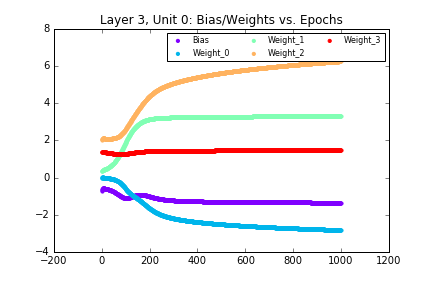
****

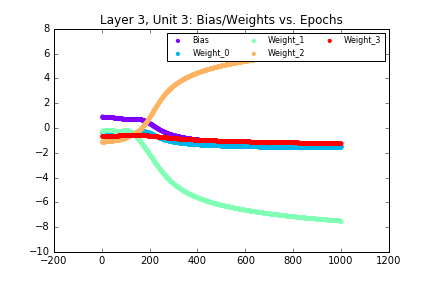
**2 inputs, 2 hidden layers, first of size 4, second of size 4, 4 output units**

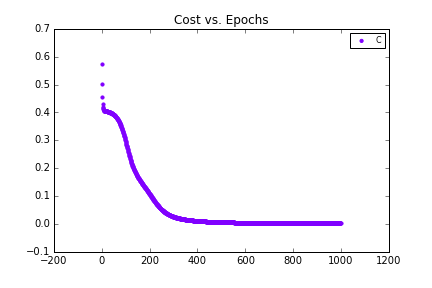
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