

# OVERVIEW

SLUG is a front end for a backprop net with 3 layers, using a sigmoid transfer function in the hidden layer and linear transfer functions in the output layer. SLUG uses the steepest descent optimization method (simple backprop). You can set the number of nodes in each layer, training parameters and transfer functions. An integrated editor allows instant access to training data and output. SLUG saves networks on dos streams.

SLUG tries to be very friendly to other Windows apps, and thus slows down a little. Still, you may find that it hogs too much CPU - let me know.

See Also

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## **Address and Contact numbers :**

### NEURAL NETWORKS TOOLKIT

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## This Release

This release contains :

- 1) A working backprop neural network application for windows (SLUG.EXE), together with the resource files (and an example for DOS).
- 2) The source code for these programs, to illustrate the use of the Toolkit.
- 3) Full documentation on the basic units contained in the Toolkit, so that you can see what it contains.

These are shareware. Please distribute these as you see fit. If you find them useful or instructive, please fill in the form below and mail it, together with \$10, (A travellers cheque is good for this...) to the given address.

Questions can be directed to me via E-mail :  
CHUCK@PSIPSY.UCT.AC.ZA or  
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## The Neural Networks Toolkit

THE NEURAL NETWORKS TOOLKIT is a set of Borland Pascal units implementing an extremely general paradigm for neural network construction.

It is not shareware, costs \$79 for people who register this release (\$89 otherwise), and contains the DOS and Windows executables (TPU and TPW for BP7) of the basic unit, NNunit and the dynamic matrices and vectors unit, Dyna2. You also get the source code for the BpNet unit, which shows how to use the basic units to construct a network object. Also included is a Croupier object which allows you to randomly "deal" from a deck of data, and some other small things, not the least of which is the ability to read the basic structure of Brainmaker files straight into your network object, including weights and data scaling capability.

You can pay for SLUG and/or the Toolkit by phone using a bank draft, Visa or Mastercard, or Travellers Cheque. If you want to use E-mail, please include your phone/fax number and your credit card number. If you use papermail, you must include a bank draft drawn on a South African bank.

See Also Address

## The basic units, Nnunit, Dyna2, and Brain.

The basic unit implements a Neuron object and a Neuralnet object, hopefully in a very general way, and defines an underlying paradigm for specific network constructions. Creating a network is easy, as the following code shows:

```
neuralnet.init(incount+hiddencount+outcount+1);
                {fully connected...}
                {insert fields}

addfield(inputfield,1,incount);
addfield(hiddenfield,incount+1, incount+hiddencount);
addfield(outputfield,incount+hiddencount+1,count-1);
addfield(offset,count,count);

setfieldsignal(hiddenfield,sigmoid);
setfieldsignal(outputfield,sigmoid);
setfieldsignal(offset,one);

setconnections;
calcallstates;  {essentially switches on offset neuron}
{-----}
procedure simpleBPnet.setconnections; {connect feedforward net}
{-----}
begin
  nofeedback;
  disconnectbetween(inputfield,outputfield);
  disconnectbetween(outputfield,inputfield);
  disconnectbetween(outputfield,hiddenfield);
  disconnectbetween(hiddenfield,inputfield);

  disconnectbetween(offset,inputfield);
  disconnectbetween(inputfield,offset);
  disconnectbetween(hiddenfield,offset);
  disconnectbetween(outputfield,offset);

  disconnect(inputfield);
  disconnect(outputfield);
  disconnect(hiddenfield);

end;
```

It essentially sees a network as a 'bag of neurons', completely connected, but divided into 'neuron fields' (think of these as subsets, not necessarily disjoint) which, for instance, you can use to define neural net layers higher up in the object hierarchy. Neurons can easily change their transfer functions, and networks can easily change their connectivity. Several neuron transfer functions are provided, and you can easily add your own.

The Dyna2 unit contains dynamic matrices and vectors, which are used in NNUnit to define connectivity, and generally run things like data presentation and training. Extensive use is made of the Tcollection object in the implementation (see the included documentation), and all objects are streamable.

The Brainmaker Unit provides the capability to interface to the results of Brainmaker training runs. You get a network object which can scale your data, and the capability to read .net files. The interface section looks like this :



## How to use SLUG

Most of the functionality of the menu is duplicated with buttons on the control panel. This area is divided into two panels, one to report progress and another to reflect current static training settings. The data count box shows how many times the dataset has been presented.

[The Panel Buttons](#)

[Training Parameters](#)

[Running a Trained Network](#)

## Training Parameters Dialog

The training parameters dialog shows the current training parameters. These are edit controls. You can only enter the data through the parameters dialog box, and not on the main control panel.

The Learning Rate

The Maximum Error Parameter

The Maximum Iterations Parameter

The Momentum Parameter



# The Panel Buttons

The Datafile/Logfile Open/Close buttons

Training Parameters

The Read net/Save net buttons

The Reset Button

The Shake Button

## **The Shake Button**

The shake button randomly perturbs the weights slightly. This is useful if you find your net stuck in a local minimum during training. Hit the shake button a couple of times to try to get out. It is also good to do this before training starts.

## **The Datafile/Logfile Open/Close buttons**

The Open buttons open the datafile or logfile. When you open a logfile, you can first check the append box to append training info to an existing logfile. The logfile holds a record of the training progress, and reports the weights matrix and performance of the net. Both data and log files must be open before training can commence.

## The Reset Button

The pause button has been removed in favour of a reset button. This resets the weights to small random numbers around zero, effectively undoing all previous training. Together with the shake button, you can now escape from unwanted local minima.

Use it during training, if you think you're well and truly stuck, and shake doesn't get you out. It has the same effect as File/New, but doesn't present you with the Network Specifications dialog.

## **The Read net/Save net buttons**

These are used to save and retrieve networks from disk. If a valid network is present, the network icon switches on and the structure of the layers is displayed. This functionality is duplicated in the File menu

## Training Parameters

The parameters menu item or button is used to set training parameters. The items presented in the dialog box are:

The Learning Rate

The Maximum Error Parameter

The Maximum Iterations Parameter

The Momentum Parameter

See also the Training parameters dialog

## The Learning Rate

This parameter effectively determines the step size during the downhill crawl of the error parameter in weight space. Setting this parameter is a black art. In general, the larger the network, the smaller this should initially be. A Ballpark figure for the 'toy' problem XOR is 0.5.

Don't panic if the error sometimes creeps up during training - this happens for various technical reasons, but usually turns around after a while. If it shoots up, you can click the parameters button during training and reduce the value.

Also remember that the weights are randomized before training starts. In all optimization methods, where you end up depends on where you start, so if your net gets stuck in a local minimum, and shaking it doesn't get you out, you may have success using the reset button to start over (i.e. the training sessions are not necessarily repeatable).

## **The Momentum Parameter**

This is a measure of how much of a previous training step is retained in the current step. Make this between 0 and 1. Usually less than 0.9.



## The Maximum Error Parameter

This is the convergence criterion. The error is calculated as

$\text{SUM}(\text{over output layer}) ( |\text{desired output} - \text{current output} | )$

## **The Maximum Iterations Parameter**

Specifies the maximum number of times the data set will be presented before the net gives up.

## Running a Trained Network

The RUN menu item reads an input file and propagates the data through the net once. This is intended for trained nets.

See also [Structure of data files](#)

## The structure of the data files

Training and running data are stored in text files. For the windows app, two ignored lines followed by any number of lines with an input/desired output pair (floating point) on each line. Eg for the XOR problem, the datafile looks like this :

```
test XOR          ----- line 1 : ignored in SLUG
4 0.5 0.8 0.0 0.1 10000 ----- line 2 : ignored in SLUG
1 1 0            ----- first IO pair
0 0 0
1 0 1
0 1 1            ----- last IO pair and last line in the file
```

In the DOS example, the first line is the title of the run, and the second line contains, in order : number of training lines, learning rate, momentum, kmod, maximum error, maximum iterations.

The log file for the above example typically looks like this :

### IO MATRIX

```
1.0000 1.0000 0.0000 ----- the matrix provided by you
0.0000 0.0000 0.0000
1.0000 0.0000 1.0000
0.0000 1.0000 1.0000
```

### DESIRED MATRIX

----- the last column of the IO matrix

```
0.0000
0.0000
1.0000
1.0000
```

### INPUT MATRIX

```
1.0000 1.0000
0.0000 0.0000
1.0000 0.0000
0.0000 1.0000
```

```
Event # 32    0.883410 ----- the error at intervals
```

Network response:

```
inputvec : 1.00    1.00 response : 0.015
inputvec : 0.00    0.00 response : 0.003
inputvec : 1.00    0.00 response : 1.002
inputvec : 0.00    1.00 response : 1.001
```

### Final Weights

```
0.0000 0.0000 -5.2722 -1.4644 0.0000 0.0000
0.0000 0.0000 -6.7207 -1.4960 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 -3.0197 0.0000
0.0000 0.0000 0.0000 0.0000 3.1998 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.7118 1.4773 -0.5769 0.0000
```

---- rows are origin of connections, columns destination, i.e. in row one, one finds that neuron 1 is connected to neurons 3 and 4, and row 5 shows that neuron 5 (the output neuron) does not provide input to anything. The last row is the offset neuron, number 6, which provides inputs to all except the two inputs and itself.

# BUGS

## KNOWN BUGS AND HASSLES (TO BE FIXED IN FUTURE RELEASES)

1. In Slug :
  - a) Make text controls which are merely informative static.
  - b) Perhaps put informative data in a separate dialog window.
  - c) Icon doesn't show when minimized.
  - d) Add graphical display of network and network training progress.
  - e) Add help.
  
2. In the Toolkit :
  - a) Add error checking for failures to allocate things on the heap. -Done
  - b) Make Croupier object index work with integer, not real dynamic vectors.
  - c) Priority one : add conjugate gradient training.
  - d) Work on second derivative training methods.
  - e) Is it worth it to implement everything using integer arithmetic only?
  - f) Add automatic data scaling. - Done. See [the Brainmaker unit](#)

Suggestions are not only very welcome, but perhaps even required.

# order form

See also [Address](#)

----- CUT HERE -----

## REGISTRATION / ORDER FORM

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PHONE : COUNTRY CODE \_\_\_\_\_ AREA CODE \_\_\_\_\_ NUMBER \_\_\_\_\_

FAX : \_\_\_\_\_

E-MAIL : \_\_\_\_\_

Mark the correct choices :

\$10 for registration of SLUG only.

\$89 for registration of SLUG and the ToolKit.

\$79 for the Toolkit Only (I have registered my copy of SLUG)

Bank draft or traveller's cheque is enclosed.

Debit my

MASTERCARD NUMBER \_\_\_\_\_

VISA CARD NUMBER \_\_\_\_\_

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