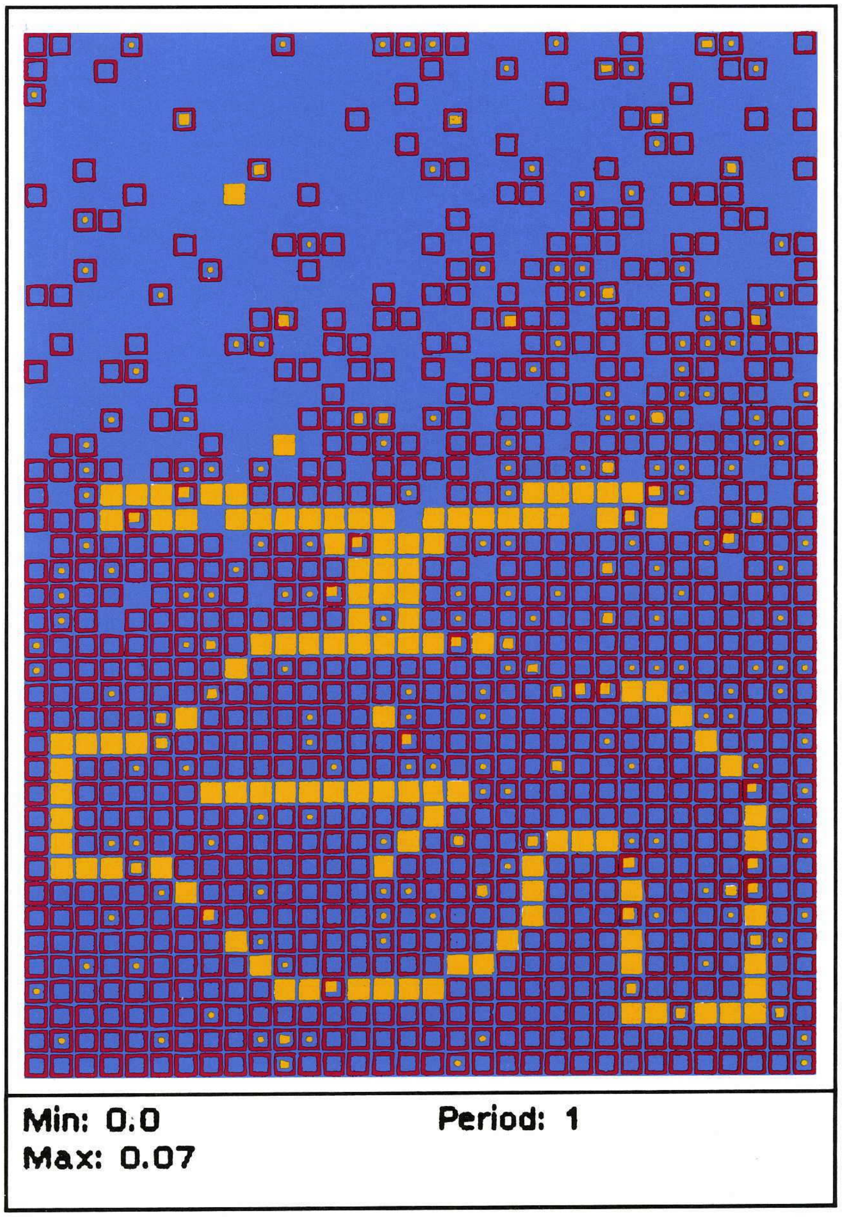
Plexi,™

An extensible, graphics-based development environment for constructing neural networks.

Plexi, Symbolics' neural network development tool, provides virtually unlimited flexibility in building neural networks. It includes all the conventional neural network models you need to build most neural networks. Yet, unlike other neural network tools which restrict you to built-in models, Plexi lets you extend its functionality by adding other neural network models or even the constituent algorithms for building entirely new models.

No other neural network tool gives you this much flexibility. And, Plexi's power is easily accessible through its graphical user interface. It's the most powerful, extensible and easy-to-use tool available today.

Plexi is the ideal solution for neural network research and for integrating neural networks with other computing solutions such as expert systems. Plus, it can be a valuable tool for developing applications that require the analysis of noisy data such as speech, signature and other pattern recognition problems.



```
Min: 0.0                          Period: 1
Max: 0.07
```

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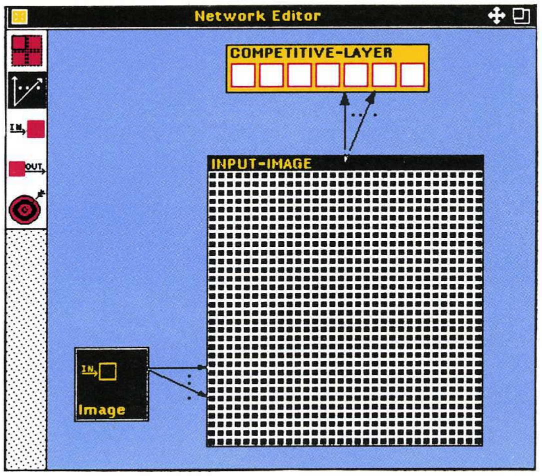
PLEXI

Plexi's Graphical User Interface Makes It Easy To Use. Plexi's menus walk you through all steps of network development, from building the network to training. It is the only neural network tool that provides so much power in such a consistent, intuitive manner.

Neural networks are inspired by theories of how biological nervous systems learn and process information. Unlike conventional computing technologies, which solve problems by executing instructions step-by-step, neural networks respond in parallel to a series of inputs.

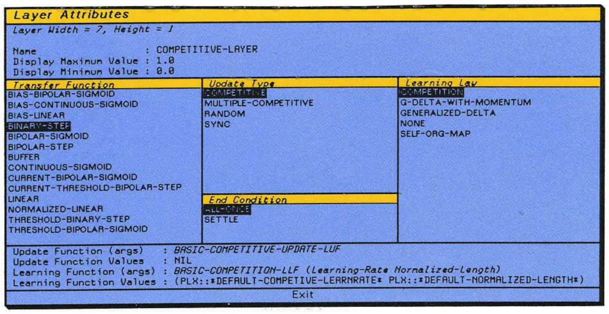
Building the Network

Plexi's network editor speeds network construction because there's no need to write code. The network architecture is represented at a very high level by just clicking on icons and drawing the layers. The architecture can be as complex or as simple as you need. In this example, we have connected an input source to INPUT-LAYER, using a predefined connectivity pattern. Initial values and processing methods default to the paradigms selected by the user, they can however be adjusted at any time.



Modifying the Attributes

You can use the wide range of attribute settings built-into Plexi including learning laws, transfer functions, and update types. Or you can modify or enhance attributes for units, layers or connections to create unique multi-paradigm networks. In this example, we changed the attributes for COMPETE-LAYER, simply by selecting the desired transfer function, update type, end condition or learning law. Plexi did the rest. This gives you unmatched flexibility in determining network characteristics.

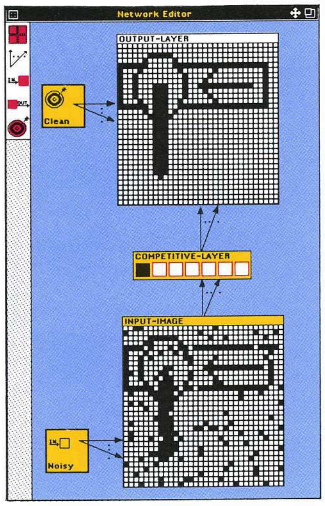


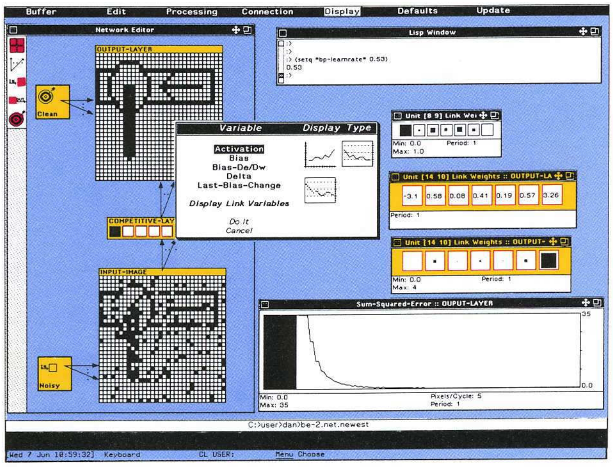
```
Layer Attributes
Layer Width = 7, Height = 1

Name                  : COMPETITIVE-LAYER
Display Maximum Value : 1.0
Display Minimum Value : 0.0
Transfer Function                    Update Type             Learning Law
BIAS-BIPOLAR-SIGMOID                 COMPETITIVE             COMPETITION
BIAS-CONTINUOUS-SIGMOID              MULTIPLE-COMPETITIVE    G-DELTA-WITH-MOMENTUM
BIAS-LINEAR                          RANDOM                  GENERALIZED-DELTA
BINARY-STEP                          SYNC                    NONE
BIPOLAR-SIGMOID                                              SELF-ORG-MAP
BIPOLAR-STEP
BUFFER
CONTINUOUS-SIGMOID
CURRENT-BIPOLAR-SIGMOID
CURRENT-THRESHOLD-BIPOLAR-STEP
LINEAR                               End Condition
NORMALIZED-LINEAR                    ALL-ONCE
THRESHOLD-BINARY-STEP                SETTLE
THRESHOLD-BIPOLAR-SIGMOID
Update Function (args)     : BASIC-COMPETITIVE-UPDATE-LUF
Update Function Values     : NIL
Learning Function (args)   : BASIC-COMPETITION-LLF (Learning-Rate Normalized-Length)
Learning Function Values   : (PLX::*DEFAULT-COMPETIVE-LEARNRATE* PLX::*DEFAULT-NORMALIZED-LENGTH*)
                                   Exit
```

Training the Network

Plexi provides a wide range of predefined learning laws to help you train the network via supervised and unsupervised learning. In this example, we are using supervised learning by supplying the response we expect the network to produce when presented with the input. Here the network is recognizing a pattern in a noisy image. Plexi supports both adaptive and nonadaptive networks.





```
:>
:>
:> (setq *bp-learnrate* 0.53)
0.53
:>
```

Min: 0.0 Period: 1
Max: 1.0

-3.1	0.58	0.08	0.41	0.19	0.57	3.26

Period: 1

Min: 0.0 Period: 1
Max: 4

Min: 0.0 Pixels/Cycle: 5
Max: 35 Period: 1

C:>user>dan>be-2.net.newest

[Wed 7 Jun 10:59:32] Keyboard CL USER:

Modifying Network Behavior

With Plexi's advanced graphics, you can easily access and analyze link, unit or layer variables using a variety of displays, including Hinton diagrams, graphs, strip charts or scatter plots. Displays can show variables from entire layers, individual cells or link bundles. In this example, we are examining the activation state of a single unit in the INPUT-LAYER, and the link weights of the connections between the COMPETE-LAYER and the OUTPUT-LAYER.

Plexi Is Easy To Use

Plexi is the only neural network tool that doesn't require you to be an expert to build neural networks. Using pull-down menus you can select defaults for the most popular neural network processing paradigms to set transfer functions, end conditions, learning laws, and update types. And Plexi saves you time because you don't have to set them individually for each layer you build.

Plexi's development tools let you quickly and easily build network structures, change and define network attributes, monitor network behavior and train the network for optimum performance. Flexible windowing, prompts, multi-tasking, and many other features help streamline operations.

Graphic Displays Simplify Development

Plexi offers unique graphic displays that represent the neural network's macro architecture—its cells, layers, and connections—as on-screen objects. Its network editor lets you create as many neural network layers as you need, and instantly connect them with a bundle of connections—all with a few mouse commands. These bundles make network connections in large groups, rather than individually, so it's easier, and less time-consuming, to build large networks.

Plexi's user interface displays the network in clear, understandable graphics and diagrams that show the network's structures, connections, and behavior. You can cut, paste, and duplicate your network, keeping training and functionality intact. And you can revise your network easily using just the mouse and pull-down menus.

As the network is running, you can quickly view the behavior of any number of network elements ranging from an individual unit to the overall network. This unique graphical environment gives you unprecedented insight and control over how your network is behaving and how its performance can be enhanced. And it allows you to move quickly from raw design to finished product.

Plexi Lets You Build Your Network Incrementally

As you build the network, Plexi lets you connect and verify layers incrementally—to ensure proper network function before you add additional layers and elements. This incremental prototyping represents a significant advantage over other neural network development tools that require you to complete much of the development work before verifying network functions. Plexi also lets you verify portions of the networks and add them to other networks, creating large scale networks from small networks whose behavioral patterns are already verified.

Plexi Is Extensible

Only Plexi makes it so easy to customize neural network processing methods to meet your specific application requirements. It doesn't limit you to the paradigms built-into the system and won't leave you behind when new paradigms become popular.

Plexi gives you access to every component of the system so you can add your own transfer functions and learning laws, develop new connectivity patterns, and define new network component attributes to explore different levels of functionality. These additions are automatically incorporated into Plexi's menus for ready access.

Extending Plexi is easy because Plexi is engineered as a software layer on top of Genera,® Symbolics' powerful object-oriented development environment. Using Genera's highly productive environment including its incremental compilation feature and fast edit-debug-compile cycle saves you time.

Plexi Lets You Experiment

Plexi makes it easy to explore new network designs and possibilities, so you can develop the optimal network for your needs. You can add or delete layers and connections to try different network structures. You can change attribute combinations to modify the characteristics of the layers and revise network behavior. You can monitor the effects of these changes as the network is running. And you can continue to modify network behavior without losing your network state.

Plexi Will Grow With Your Needs

Plexi gives you virtually unlimited control over the number of units, layers, and connections in your neural network. You can build networks as big as you need—and still have room to expand, revise, or adapt them for new applications. The only limitation is the size of your virtual address space.

Plexi Works With Today's Technologies

Plexi can be used in conjunction with Symbolics' proven development and delivery tools including, Joshua,™ Symbolics environment for building and delivering expert systems; Symbolics Concordia™ a hypertext document management system; and Statice™ Symbolics' object-oriented database. Plexi also can be integrated with a variety of languages including Symbolics C,™ Symbolics Pascal,™ and Symbolics FORTRAN® to build real-world applications.

Input to the network is analyzed by processing units, called cells, grouped into layers performing a subtask of the application. Neural networks consist of one or more such layers. The network is then trained to respond correctly when presented with specific input, or it can be structured to teach itself to recognize features within the input; this response forms the network's output.

Neural networks are valuable for applications where the expected solution cannot be clearly defined, where the data is incomplete or variable or where the solution requires inductive or heuristic reasoning.

Put Plexi To Work Today

If your applications require the leading edge of technology, you need Plexi. No other neural network development environment available today can match Plexi's power and flexibility. And no other neural network development environment can make you so productive so quickly.

To put Plexi to work on your neural network development challenges, contact your local Symbolics representative today or call (800) 237-2401.

PLEXI SPECIFICATIONS

Hardware:	Symbolics 3600 series systems MacIvory and XL400 workstations
Size:	Maximum number of units per layer, layers per network, connections between units, input/output/training sources is limited only by virtual address space.
Processing Speed:	65,000 connections per second
Industry-Standard Paradigms:	Hopfield Memory Competition Back Propagation
Built-in Network Options:	
Transfer Functions:	More than 20 built-in Transfer Functions including Linear, Sigmoid, and Binary Step. Plus users can write their own.
Learning Laws:	A range of built-in Learning Laws including Back Propagation, Competition, and Self-Organizing Map. Plus users can write their own.
Display Capabilities:	
Graphics:	Histograms Strip charts Scatter charts "Growing box" proportional diagrams "Hinton" diagrams
Displayable values per unit or layer:	Activation Threshold Link weights Variables defined by links, units, layers
Connectivity Between Layers:	
Predefined:	Full Full, except self
Random:	
Connection Patterns:	User specified via Pattern Editor
User Function:	User specified via Lisp function
Programmable in:	Symbolics Common Lisp Symbolics C Symbolics FORTRAN Symbolics Pascal
Compatible With:	Joshua Statice Symbolics Concordia

For further information on Plexi, contact:

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Neural Network Glossary

Activation state:

Output value of a cell, computed via a transfer function from the cell's input links and their associated weights.

Attributes:

Characteristics of an object which describe its function. Layer attributes include transfer function, update type, learning law, etc. Cell attributes include activation value and change over time, etc. Bundle attributes include connectivity pattern.

Bundle:

A collection of links between layers.

End condition:

Condition for terminating the transfer function computation within a layer. E.g., compute each cell's activation value only once, or recompute until the cell's activation values stop changing.

Layer:

A group of one or more cells, all of which share a common transfer function. Computation of the transfer function is controlled by the layer's update type. Adjustment of the link weights is controlled by the layer's learning law.

Learning law:

Algorithm for adjusting the link weights of the cells comprising a layer to correct the layer's response to input. Correction provided by user-supplied function or data is termed supervised learning; networks can correct themselves via unsupervised learning.

Link:

Provides one cell's output value as the input value to another cell. A link can connect a cell to itself, providing feedback.

Network paradigm:

A conventional selection of transfer function, update type, learning law, and end condition method. E.g., Back Propagation, Competition, and Hopfield Memory.

Processing unit or cell:

Computes via a transfer function an output value, the activation value, based upon the cell's input values and their link weights. The basic component from which a neural network is built.

Transfer function:

Algorithm for computing a cell's activation value based upon the cell's input value and their link weights.

Update type:

Method for updating the activation values of cells within a layer. E.g., randomly in no particular order, synchronously or all at once, or competitively where cells vie with one another for completion.

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