Introduction Standard

Hello,

Thank you for agreeing to do this survey!

For this survey, you will be asked to use 2 different types of decision-making frameworks and rate them based on their interpretability.

I will first provide you with instructions on how to use a certain type of decision-making framework. After this, I will ask you to click to the "next" button and use the decision-making framework to trace an input to an output. **I will ask that you do not take breaks on this page, as the speed at which you complete this exercise is timed**. At this point, you will be asked to answer some subjective questions about the decision-making framework used and the overall process of choosing a decision given the method.

This process will be repeated two times for two different decision-making frameworks. This should take you approximately 15 minutes.

Please have a paper, writing utensil, and calculator at hand as you may need keep track of up to 10 numbers at once. You may use a code editor as a calculator but please do not use it to assist with matrix multiplication. **As compensation, you will receive a $5 Amazon gift card.** Note that you must meet a minimum precalculated survey statistic to receive the compensation.

This survey has been approved by the Georgia Institute of Technology IRB. We recommend that you conduct this survey on your computer rather

than on a mobile device.

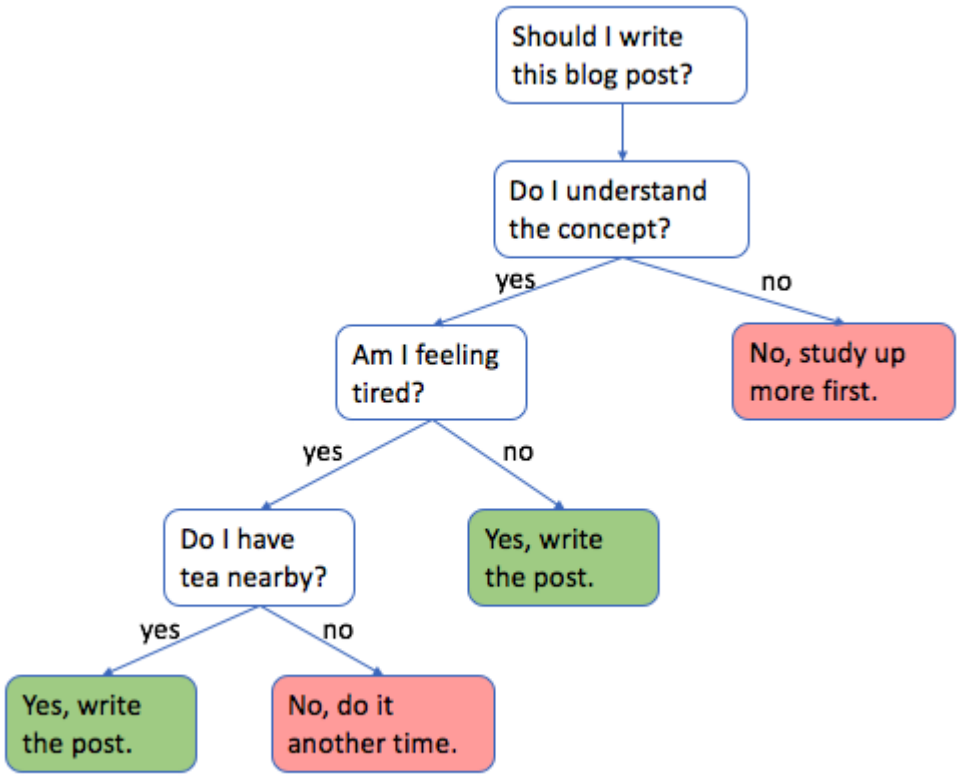
Standard Decision Tree Introduction

A standard decision tree is a decision-making model in which each internal node represents a “test” on an attribute (e.g. whether you have completed your homework), each branch represents the outcome of the test, and each leaf node represents a class label (e.g., you can go play outside). The paths from root to leaf represent classification rules.

In our trees, moving LEFT in the decision tree is associated a "test" of an attribute being true.

Let's do a quick example.

Standard Decision Tree representing the decision of "Should I write a blog post?".



In the decision tree above, the input into the decision tree would [Do I understand the concept?, Do I feel tired?, Do I have tea nearby?] and the outputs are either yes or no.

For example,

If we received the input of [yes, yes, no], the output would be No.

On the next page, you will be given a decision tree representing scheduling behavior. Given input data about the difficulty of three tasks and whether the scheduler prefers to handle difficult tasks or easy tasks, you will have to use the decision tree given to decide which task to schedule.

The input array will be of size 5, and the decision tree will reference the corresponding element using {#} notation.

For example, for the input data of [11, 22, 33, 44, 55], {3} refers to 33.

Standard Decision Tree Test

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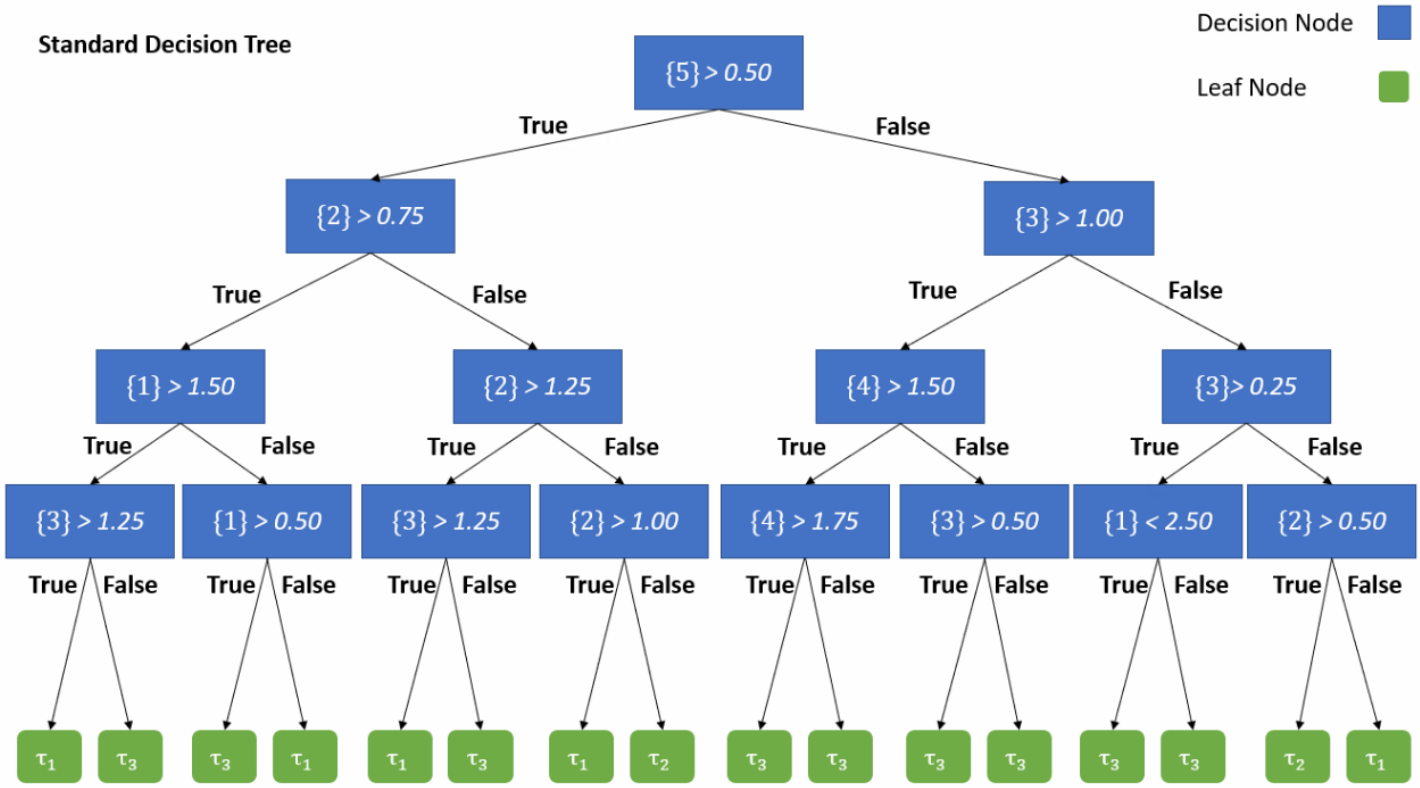
Input data:

[2, 1, 3, 0.40, 0.60]

Standard decision tree representing scheduling behavior.



What is the output of this decision tree given the input above? Please type the number in the subscript.

For example, if the output you receive is tau_25, you would type 25.

Standard Decision Tree Survey

Please fill out the questions below. The phrase "decision-making model" refers specifically to the graphic on the previous page. The phrase overall "decision-making process" refers to the entire process starting from being given input(s) to answering the question(s).

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model is interpretable.	○	○	○	○	○	○	○

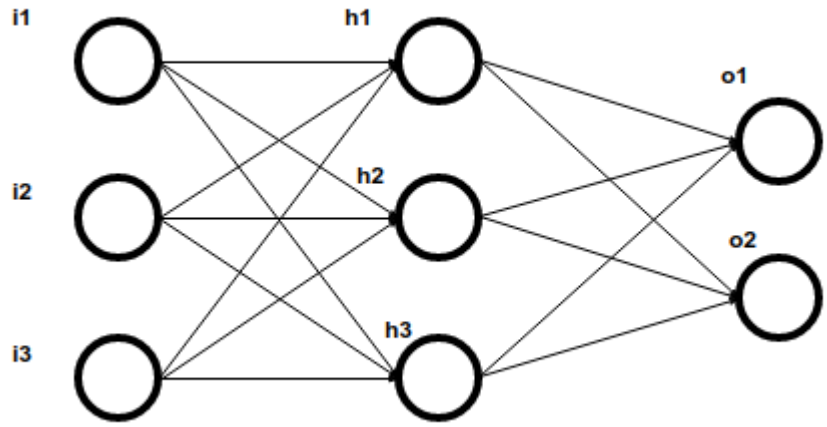
	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
I understand the behavior represented within the decision-making model.	○	○	○	○	○	○	○
The decision-making model logic is easy to follow.	○	○	○	○	○	○	○
The decision-making model does not make sense.	○	○	○	○	○	○	○
The decision-making model is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making model with ease.	○	○	○	○	○	○	○
I like the level of readability of this decision-making model.	○	○	○	○	○	○	○
The overall decision-making process is easy to comprehend.	○	○	○	○	○	○	○
I understand the overall process of choosing an output given input(s).	○	○	○	○	○	○	○
This overall decision-making process logic is easy to follow.	○	○	○	○	○	○	○
The overall decision-making process does not make sense.	○	○	○	○	○	○	○
The overall decision-making process is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making tool with ease.	○	○	○	○	○	○	○

Standard Neural Network Introduction

A standard neural network is decision-making model in which a set of inputs (e.g., hours of homework per week) are transformed through multiplication and activation functions to produce an output (e.g., will you ace your math test?).

Let's do a quick example.

Neural network example

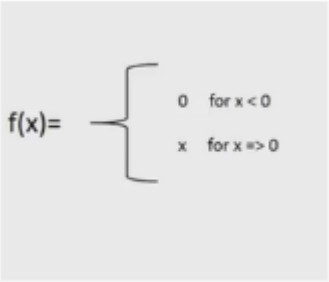


The above neural network has 3 input nodes (represented by the 3 nodes in the left-most of the diagram), 3 hidden nodes (represented by the 3 nodes in the middle of the diagram and 2 output nodes.

For our example, the 3 input nodes (features) refer to [how many hours of homework you do a day, how many video games you play a day, and how many hours you read a day] and the 2 output nodes refer to the likelihood of receiving a failing grade on your math test, and the likelihood of receiving a passing mark on your math test.

Say our input features are [1,0,2] corresponding to 1 hours of homework a day, 0 video games, and 2 hours of reading.

Relu Function



Softmax Function

$$\text{Softmax}(x_i) = \frac{\exp(x_i)}{\sum_j \exp(x_j)}$$

Weights of the neural network

$$W_1 = \begin{array}{c} \\ h1 \\ h2 \\ h3 \end{array} \begin{array}{c} \begin{array}{ccc} i1 & i2 & i3 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 1 \\ 3 & 0 & 2 \end{bmatrix} \end{array}$$

$$B_1 = \begin{array}{c} \\ b1 \\ b2 \\ b3 \end{array} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

$$W_2 = \begin{array}{c} \\ o1 \\ o2 \end{array} \begin{array}{c} \begin{array}{ccc} h1 & h2 & h3 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 \\ 3 & 1 & 2 \end{bmatrix} \end{array}$$

$$B_2 = \begin{array}{c} \\ b1 \\ b2 \end{array} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

The outputs o1 and o2 can be computed through the equation below.

H = W_1 * x + B_1

H = ReLU(H)
O = W_2 * H + B_2

Here, x is our input column vector [1,0, 2]
W_1, W_2, B_1, and B_2 are shown in the images.

The multiplication of H breaks down to
To get to value of h1, we do (1 * 1 + 0 * 0 + 2 * 0) + 1 = 2
To get to value of h2, we do (1 * 2 + 0 * 1 + 2 * 1) + 0 = 4
To get to value of h3, we do (1 * 3 + 0 * 2 + 2 * 2) + 0 = 7

The ReLU function is discussed above. For the vector H, it turns all negative numbers to 0, and leaves all positive the same. Thus, the ReLU function has no effect.

The computation of O breaks down to
To get to value of o1, we do (1 * 0 + 4 * 0 + 7 * 0) + 0 = 0
To get to value of o2, we do (1 * 3 + 4 * 1 + 7 * 2) + 1 = 22

To compute final probabilities, we will utilize the softmax function (shown above).
o1 = e^0 / (e^0+ e^22) = 2.78e^-10
o2 = e^21 / (e^0 + e^21) = 1

Feel free to try this example on your calculator.

On the next page, you will be given a neural network representing scheduling behavior. Given input data about three tasks, you will have to use the neural network given to decide which task to schedule.

The input array will be of size 4. i1 will correspond to the first element, and so forth.

For example, for the input data of [11, 22, 33, 44, 55, 66, 77], i4 corresponds to 44.

Standard Neural Network Test

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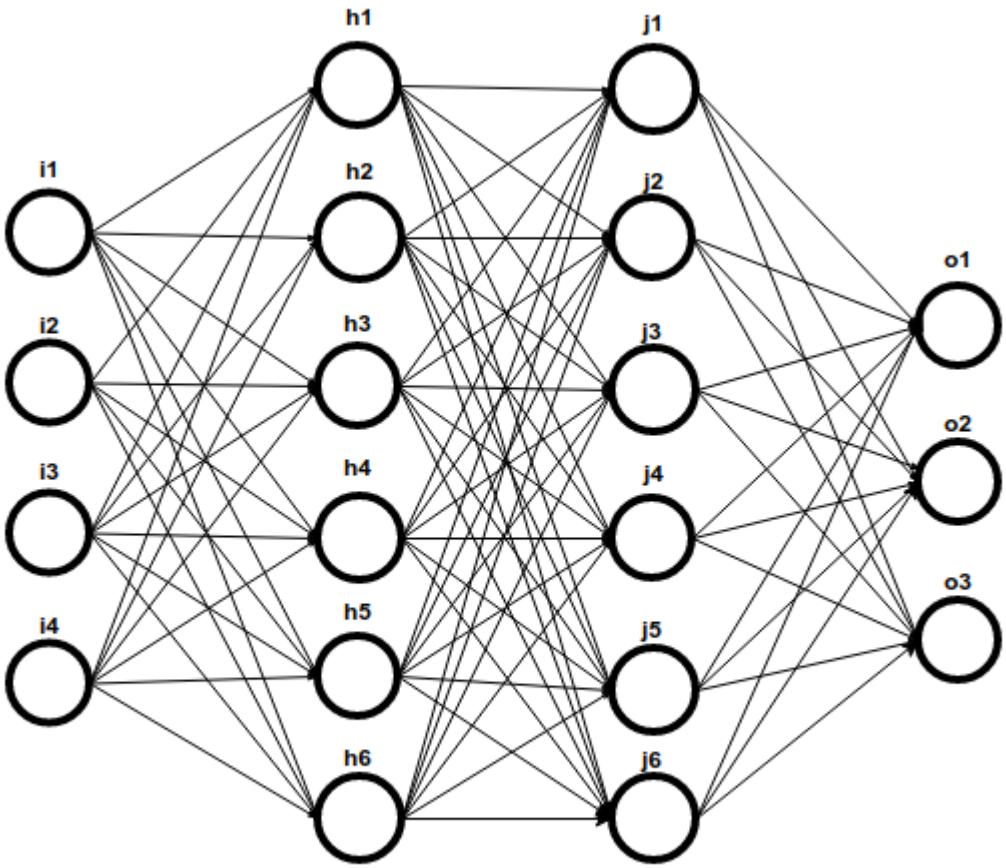
Input data:

[1, 2, 3, 1]

The outputs of the neural network correspond to Task 1, Task 2, and Task 3.

Note that the ReLU function is applied after the hidden layer. Simply, this function transforms any number below 0 to 0, and any other number stays the same. After computing o1, o2, o3, please apply the softmax function.



$$W_1 = \begin{array}{c} \\ h1 \\ h2 \\ h3 \\ h4 \\ h5 \\ h6 \end{array} \begin{array}{c} \begin{array}{cccc} i1 & i2 & i3 & i4 \end{array} \\ \begin{bmatrix} 0 & -0.5 & 0 & -0.5 \\ 0 & -0.25 & 0 & 0 \\ 0 & 1.25 & -1 & 1.75 \\ -1 & 1 & 0.5 & -2.25 \\ 2 & -0.25 & -1.5 & 3.5 \\ 1 & 0.5 & -1.5 & -1.5 \end{bmatrix} \end{array}$$

$$B_1 = \begin{array}{c} \\ b1 \\ b2 \\ b3 \\ b4 \\ b5 \\ b6 \end{array} \begin{array}{c} \\ \begin{bmatrix} -0.25 \\ 0 \\ -0.5 \\ 0.5 \\ 0 \\ 0 \end{bmatrix} \end{array}$$

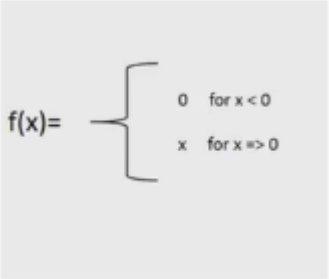
$$W_2 = \begin{array}{c} \\ j1 \\ j2 \\ j3 \\ j4 \\ j5 \\ j6 \end{array} \begin{array}{c} \begin{array}{cccccc} h1 & h2 & h3 & h4 & h5 & h6 \end{array} \\ \begin{bmatrix} -0.5 & -0.25 & -1.75 & 3.5 & -4 & -0.25 \\ 0 & 0 & -1 & 0.75 & 3.25 & 2.75 \\ 0.25 & -0.25 & 2.25 & -0.75 & -0.25 & -0.25 \\ -0.25 & 0 & 1.75 & -0.25 & 2.75 & -2.5 \\ 0.25 & -0.5 & -1.75 & 3.5 & -4.5 & -0.25 \\ 0.25 & 0 & -2.75 & -2.25 & -0.75 & 1.5 \end{bmatrix} \end{array}$$

$$B_2 = \begin{array}{c} \\ b1 \\ b2 \\ b3 \\ b4 \\ b5 \\ b6 \end{array} \begin{array}{c} \\ \begin{bmatrix} 1.25 \\ 0 \\ 3 \\ -3.5 \\ 0.75 \\ 4.5 \end{bmatrix} \end{array}$$

$$W_3 = \begin{array}{c} \\ o1 \\ o2 \\ o3 \end{array} \begin{array}{c} \begin{array}{cccccc} j1 & j2 & j3 & j4 & j5 & j6 \end{array} \\ \begin{bmatrix} 2.25 & -0.75 & -6 & 0 & 2.5 & -15.5 \\ -6.75 & -5.25 & 0.75 & 1 & -7 & 2 \\ -2 & 6 & -2.75 & -21.5 & 1.5 & -2 \end{bmatrix} \end{array}$$

$$B_3 = \begin{array}{c} \\ b1 \\ b2 \\ b3 \end{array} \begin{array}{c} \\ \begin{bmatrix} -3.5 \\ 0 \\ 0.5 \end{bmatrix} \end{array}$$

Relu Function



Softmax Function

$$\text{Softmax}(x_i) = \frac{\exp(x_i)}{\sum_j \exp(x_j)}$$

Please fill in each question below. Please round to 3 decimal places.

h1 (before ReLU)

h2 (before ReLU)

h3 (before ReLU)

h4 (before ReLU)

h5 (before ReLU)

h6 (before ReLU)

j1 (before ReLU)

j2 (before ReLU)

j3 (before ReLU)

j4 (before ReLU)

j5 (before ReLU)

j6 (before ReLU)

o1 (after softmax)

o2 (after softmax)

o3 (after softmax)

What is the output of this neural network given the input above? Please type the number associated with the output/task?

For example, if the output you receive is Task 5 has the highest score, you would type "5".

Standard Neural Network Survey

Please fill out the questions below. The phrase "decision-making model" refers specifically to the graphic on the previous page. The phrase overall "decision-making process" refers to the entire process starting from being given input(s) to answering the question(s).

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model is interpretable.	○	○	○	○	○	○	○
I understand the behavior represented within the decision-making model.	○	○	○	○	○	○	○
The decision-making model logic is easy to follow.	○	○	○	○	○	○	○
The decision-making model does not make sense.	○	○	○	○	○	○	○
The decision-making model is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making model with ease.	○	○	○	○	○	○	○
I like the level of readability of this decision-making model.	○	○	○	○	○	○	○

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The overall decision-making process is easy to comprehend.	○	○	○	○	○	○	○
I understand the overall process of choosing an output given input(s).	○	○	○	○	○	○	○
This overall decision-making process logic is easy to follow.	○	○	○	○	○	○	○
The overall decision-making process does not make sense.	○	○	○	○	○	○	○
The overall decision-making process is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making tool with ease.	○	○	○	○	○	○	○

Introduction Pointwise

Hello,

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For this survey, you will be asked to use 2 different types of decision-making frameworks and rate them based on their interpretability.

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method.

This process will be repeated two times for two different decision-making frameworks. This should take you approximately 35 minutes.

Please have a paper, writing utensil, and calculator at hand as you may need keep track of up to 10 numbers at once. You may use a code editor as a calculator but please do not use it to assist with matrix multiplication. **As compensation, you will receive a $10 Amazon gift card.** Note that you must meet a minimum precalculated survey statistic to receive the compensation.

This survey has been approved by the Georgia Institute of Technology IRB. We recommend that you conduct this survey on your computer rather than on a mobile device.

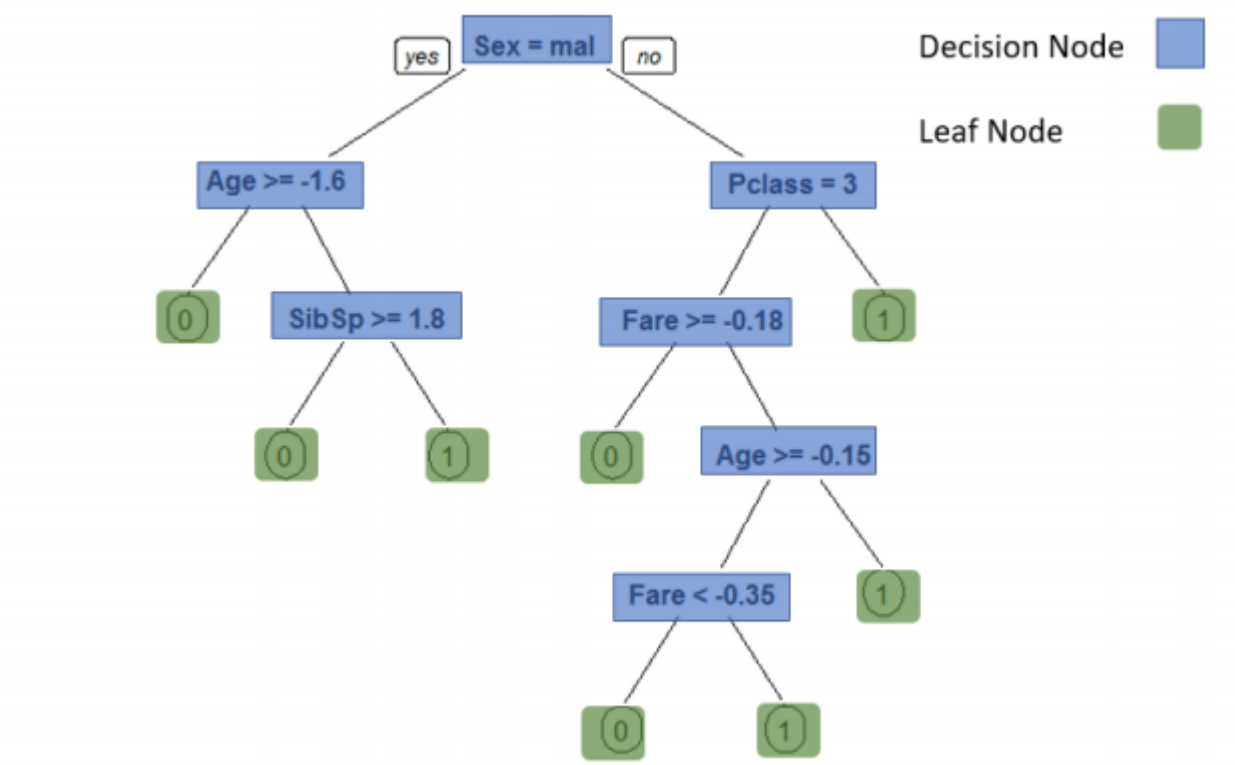
Pointwise Decision Tree Introduction

A pointwise decision tree is a decision-making model in which each internal node represents a “test” on an attribute (e.g. whether a coin flip comes up heads or tails), each branch represents the outcome of the test, and each leaf node represents a score for the input. For this tree, you will be given a set of inputs, each corresponding to a specific output class. You must plug each input into the tree, and choose the input associated with the highest score.

In our trees, moving LEFT in the decision tree is associated a "test" of an attribute being true.

Let's do a quick example. Say you are given three inputs, representing some information about 3 people.
A: [Male, Age=2, SibSp=2, Pclass=3, Fare=4],
B: [Female, Age=2, SibSp=2, Pclass=2, Fare=4],
C:[Female, Age=2, SibSp=2, Pclass=3, Fare=4].

You put each input through the tree below and you will get scores of 0,1,0 for A,B,C respectively. We choose B as the output as it has the highest score.



On the next page, you will be given a decision tree representing scheduling behavior. Given input data about the difficulty of three tasks and whether the scheduler prefers to handle difficult tasks or easy tasks, you will have to use the decision tree given to decide which task to schedule.

For example, for the input data of [11, 22, 33, 44, 55], {3} refers to 33.

Pointwise Decision Tree Test

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Input data:

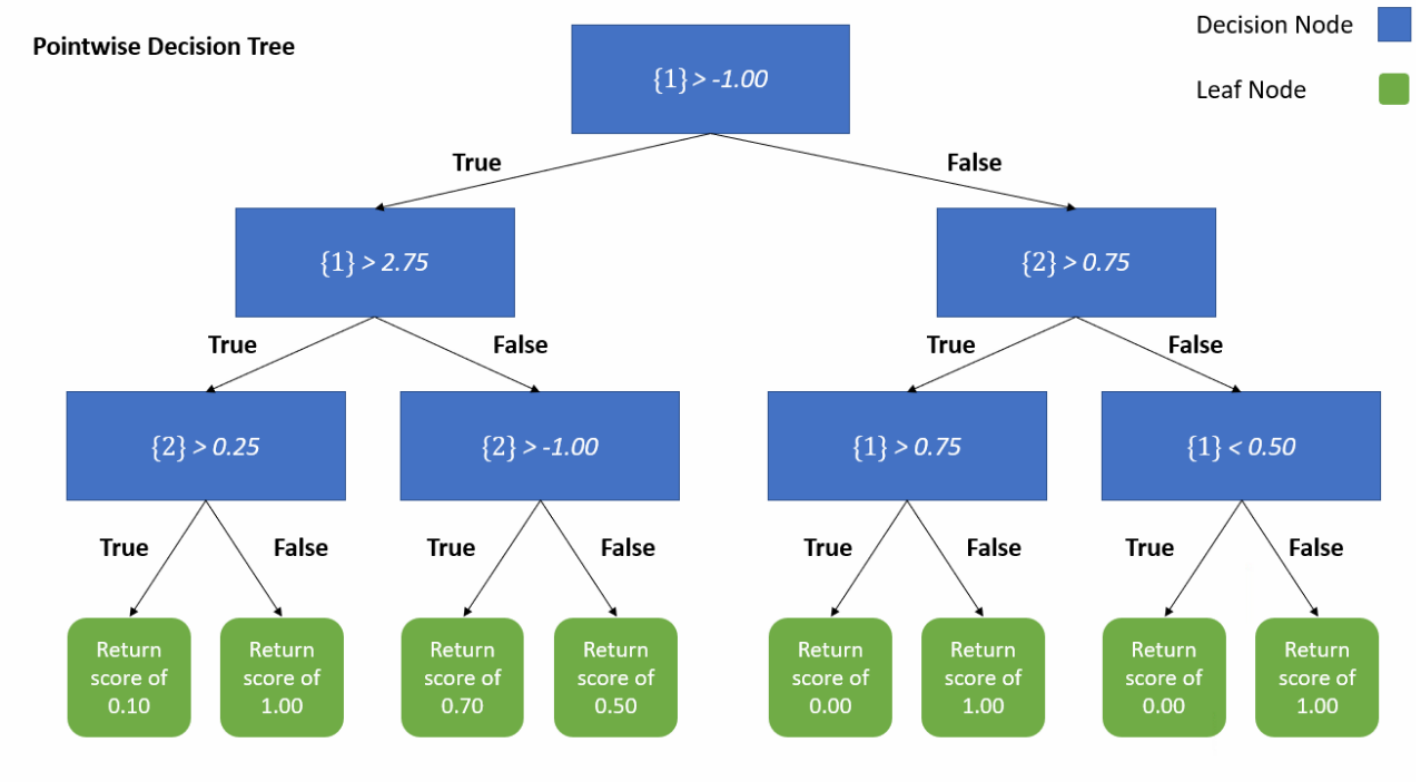
Task 1: [3]
Task 2: [2]
Task 3: [1]

{2} fixed to 0.1

Clarification: The data for each task is feature {1}. {2} is fixed to 0.1.

The instructions from the previous page are found at the bottom of this page. Note that the previous page used Person 1, Person 2, and Person 3 and here we use Task 1, Task 2, and Task 3.

Pointwise decision tree representing scheduling behavior.



Please write the scores of each task.

Task 1 Score

Task 2 Score

Task 3 Score

What is the output of this decision tree given the input above? Please type the number of the task. In the case of ties, break ties using numerical order.

For example, if the output you receive is task 5 has the highest score, you would type 5.

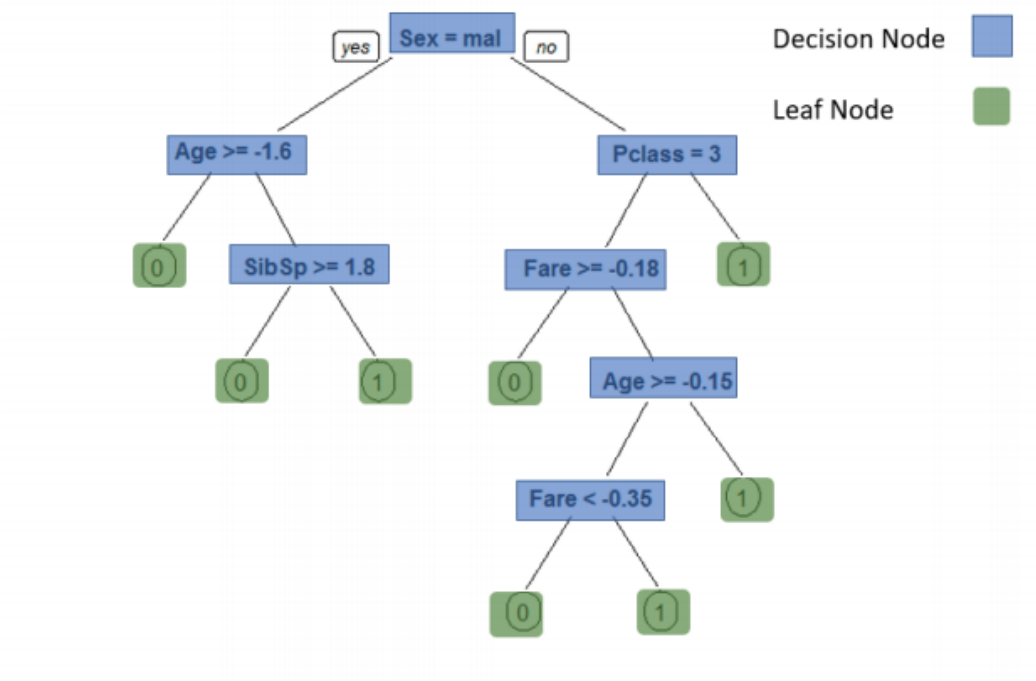
Instructions for Pointwise DT

A pointwise decision tree is a decision-making model in which each internal node represents a “test” on an attribute (e.g. whether a coin flip comes up heads or tails), each branch represents the outcome of the test, and each leaf node represents a score for the input. For this tree, you will be given a set of inputs, each corresponding to a specific output class. You must plug each input into the tree, and choose the input associated with the highest score.

In our trees, moving LEFT in the decision tree is associated a "test" of an attribute being true.

Let's do a quick example. Say you are given three inputs,
A: [Male, Age=2, SibSp=2, Pclass=3, Fare=4],
B: [Female, Age=2, SibSp=2, Pclass=2, Fare=4],
C:[Female, Age=2, SibSp=2, Pclass=3, Fare=4].

You put each input through the tree below and you will get scores of 0,1,0 for A,B,C respectively. We choose B as the output as it has the highest score.



On the next page, you will be given a decision tree representing scheduling behavior. Given input data about the difficulty of three tasks and whether the scheduler prefers to handle difficult tasks or easy tasks, you will have to use the decision tree given to decide which task to schedule.

For example, for the input data of [11, 22, 33, 44, 55], {3} refers to 33.

Pointwise Decision Tree Survey

Please fill out the questions below. The phrase "decision-making model" refers specifically to the graphic on the previous page. The phrase overall "decision-making process" refers to the entire process starting from being given input(s) to answering the question(s).

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model is interpretable.	○	○	○	○	○	○	○

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
I understand the behavior represented within the decision-making model.	○	○	○	○	○	○	○
The decision-making model logic is easy to follow.	○	○	○	○	○	○	○
The decision-making model does not make sense.	○	○	○	○	○	○	○
The decision-making model is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making model with ease.	○	○	○	○	○	○	○
I like the level of readability of this decision-making model.	○	○	○	○	○	○	○
The overall decision-making process is easy to comprehend.	○	○	○	○	○	○	○
I understand the overall process of choosing an output given input(s).	○	○	○	○	○	○	○
This overall decision-making process logic is easy to follow.	○	○	○	○	○	○	○
The overall decision-making process does not make sense.	○	○	○	○	○	○	○
The overall decision-making process is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making tool with ease.	○	○	○	○	○	○	○

Pointwise Neural Network Introduction

Here, we introduce pointwise neural networks.

Please pay attention as you will not be allowed to come back and view this page.

In the neural network below, the input into the neural network would be the input features [How much homework does the person do?, How many video games does the person play?, What is the work rate of the person?].

Say you are given three inputs,
Person 1: [Homework = 10, Video Games = 3, Utility = 1],
Person 2: [Homework = 3, Video Games = 4, Utility = 0],
Person 3: [Homework = 14, Video Games = 3, Utility = 14].

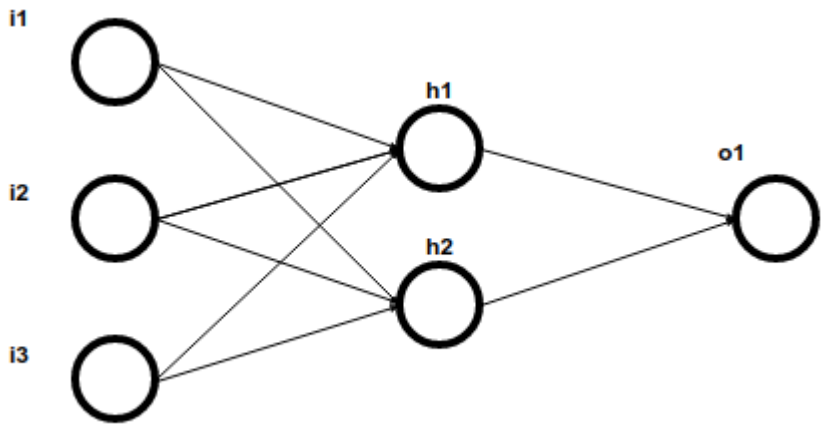
We can find the output of our network in matrix form using the equations:
$H = W_1 * x + B_1$
$H = ReLU(H)$
$O = W_2 * H + B_2$

$$W_1 = \begin{matrix} \\ h1 \\ h2 \end{matrix} \begin{matrix} i1 & i2 & i3 \\ \end{matrix} \begin{bmatrix} 1 & 0 & 1 \\ 3 & 0 & 2 \end{bmatrix}$$

$$B_1 = \begin{matrix} b1 \\ b2 \end{matrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$W_2 = \begin{matrix} \\ o1 \end{matrix} \begin{matrix} h1 & h2 \\ \end{matrix} \begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$B_2 = \begin{matrix} b1 \end{matrix} \begin{bmatrix} 1 \end{bmatrix}$$



The scores of each person can be computed by inputting each into the neural network. To compute the output of Person 1 = [10, 3, 1],

To get to value of h1, we do (10 * 1 + 3 * 0 + 1 * 1) + 0 = 11
To get to value of h2, we do (10 * 3 + 3 * 0 + 1 * 2) + 1 = 33

Now we apply the ReLU activation function to h1 and h2 (shown below). Simply, this function transforms any number below 0 to 0, and any other number stays the same. Since h1 and h2 are positive, they remain unchanged.

To find o1, we do (11 * 0 + 33 * 1) + 1 = 34 to get the value score of o1.

We can do this for each input and put the outputs into the following vector form.

$$\begin{bmatrix} \text{Person 1} \\ \text{Person 2} \\ \text{Person 3} \end{bmatrix} = \begin{bmatrix} 34 \\ 11 \\ 72 \end{bmatrix}$$

Since Person C has the highest score, we choose person C.

On the next page, you will be given a neural network representing scheduling behavior. Given input data about three tasks, you will have to use the neural network given to decide which task to schedule.

The input array will be of size 5. i1 will correspond to the first element, and so forth.

For example, for the input data of [11, 22, 33, 44, 55, 66, 77], i4 corresponds to 44.

Pointwise Neural Network Test

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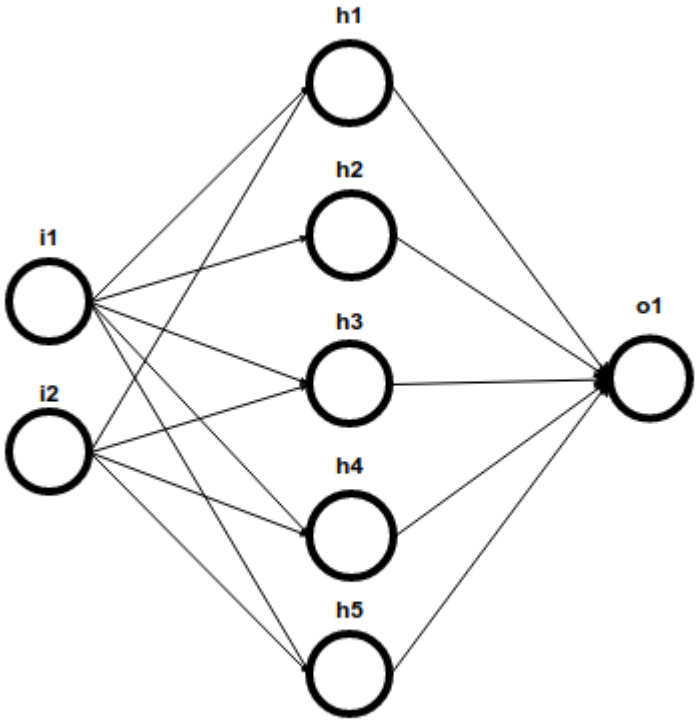
Input data:

Task 1: [1]
Task 2: [2]
Task 3: [3]

The instructions found on the previous page are attached at the end of this page for reference.

Pointwise neural network representing scheduling behavior. A ReLU is applied after layer 1.



i2 is fixed to 1.

$$W_1 = \begin{array}{c} \\ h1 \\ h2 \\ h3 \\ h4 \\ h5 \end{array} \begin{array}{c} \begin{array}{cc} i1 & i2 \end{array} \\ \begin{bmatrix} 0.25 & -0.5 \\ -0.25 & -0.75 \\ -0.25 & -0.5 \\ -2.25 & -0.25 \\ -0.75 & 3.25 \end{bmatrix} \end{array}$$

$$B_1 = \begin{array}{c} \\ b1 \\ b2 \\ b3 \\ b4 \\ b5 \end{array} \begin{array}{c} \begin{array}{c} \end{array} \\ \begin{bmatrix} -0.5 \\ -0.25 \\ 0 \\ 2 \\ -0.75 \end{bmatrix} \end{array}$$

$$W_2 = \begin{array}{c} \\ o1 \end{array} \begin{array}{c} \begin{array}{ccccc} j1 & j2 & j3 & j4 & j5 \end{array} \\ \begin{bmatrix} -0.5 & -0.25 & -0.25 & 2 & -5 \end{bmatrix} \end{array}$$

$$B_2 = \begin{array}{c} \\ b1 \end{array} \begin{array}{c} \begin{array}{c} \end{array} \\ \begin{bmatrix} -0.25 \end{bmatrix} \end{array}$$

Please write the final scores below.

Task 1 Score

Task 2 Score

Task 3 Score

What is the output of this neural network given the input above? Please type the number of the task. In the case of ties, break ties using numerical order.

For example, if the output you receive is task 5 has the highest score, you would type 5.

Here, we introduce pointwise neural networks.

Please pay attention as you will not be allowed to come back and view this page.

In the neural network below, the input into the neural network would be the input features [How much homework does the person do?, How many video games does the person play?, What is the work rate of the person?].

Say you are given three inputs,
Person 1: [Homework = 10, Video Games = 3, Utility = 1],
Person 2: [Homework = 3, Video Games = 4, Utility = 0],
Person 3: [Homework = 14, Video Games = 3, Utility = 14].

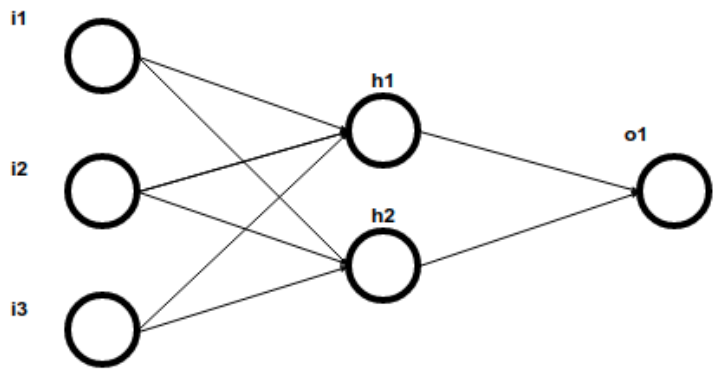
We can find the output of our network in matrix form using the equations:
$H = W_1 * x + B_1$
$H = ReLU(H)$
$O = W_2 * H + B_2$

$$W_1 = \begin{matrix} \\ h1 \\ h2 \end{matrix} \begin{matrix} i1 & i2 & i3 \\ \end{matrix} \begin{bmatrix} 1 & 0 & 1 \\ 3 & 0 & 2 \end{bmatrix}$$

$$B_1 = \begin{matrix} b1 \\ b2 \end{matrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$W_2 = \begin{matrix} \\ o1 \end{matrix} \begin{matrix} h1 & h2 \\ \end{matrix} \begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$B_2 = \begin{matrix} b1 \end{matrix} \begin{bmatrix} 1 \end{bmatrix}$$



The scores of each person can be computed by inputting each into the neural network. To compute the output of Person 1 = [10, 3, 1],

To get to value of h1, we do (10 * 1 + 3 * 0 + 1 * 1) + 0 = 11
To get to value of h2, we do (10 * 3 + 3 * 0 + 1 * 2) + 1 = 33

Now we apply the ReLU activation function to h1 and h2 (shown below). Simply, this function transforms any number below 0 to 0, and any other number stays the same. Since h1 and h2 are positive, they remain unchanged.

To find o1, we do (11 * 0 + 33 * 1) + 1 = 34 to get the value score of o1.

We can do this for each input and put the outputs into the following vector form.

$$\begin{bmatrix} \text{Person 1} \\ \text{Person 2} \\ \text{Person 3} \end{bmatrix} = \begin{bmatrix} 34 \\ 11 \\ 72 \end{bmatrix}$$

Since Person C has the highest score, we choose person C.

On the next page, you will be given a neural network representing scheduling behavior. Given input data about three tasks, you will have to use the neural network given to decide which task to schedule.

The input array will be of size 5. i1 will correspond to the first element, and so forth.

For example, for the input data of [11, 22, 33, 44, 55, 66, 77], i4 corresponds to 44.

Pointwise Neural Network Survey

Please fill out the questions below. The phrase "decision-making model" refers specifically to the graphic on the previous page. The phrase overall "decision-making process" refers to the entire process starting from being given input(s) to answering the question(s).

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model is interpretable.	○	○	○	○	○	○	○

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
I understand the behavior represented within the decision-making model.	○	○	○	○	○	○	○
The decision-making model logic is easy to follow.	○	○	○	○	○	○	○
The decision-making model does not make sense.	○	○	○	○	○	○	○
The decision-making model is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making model with ease.	○	○	○	○	○	○	○
I like the level of readability of this decision-making model.	○	○	○	○	○	○	○
The overall decision-making process is easy to comprehend.	○	○	○	○	○	○	○
I understand the overall process of choosing an output given input(s).	○	○	○	○	○	○	○
This overall decision-making process logic is easy to follow.	○	○	○	○	○	○	○
The overall decision-making process does not make sense.	○	○	○	○	○	○	○
The overall decision-making process is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making tool with ease.	○	○	○	○	○	○	○

Introduction Pairwise

Hello,

Thank you for agreeing to do this survey!

For this survey, you will be asked to use 2 different types of decision-making frameworks and rate them based on their interpretability.

I will first provide you with instructions on how to use a certain type of decision-making framework. After this, I will ask you to click to the "next" button and use the decision-making framework to trace an input to an output. **I will ask that you do not take breaks on this page, as the speed at which you complete this exercise is timed**. At this point, you will be asked to answer some subjective questions about the decision-making framework used and the overall process of choosing a decision given the method.

This process will be repeated two times for two different decision-making frameworks. This should take you approximately 1 hour.

Please have a paper, writing utensil, and calculator at hand as you may need keep track of up to 10 numbers at once. You may use a code editor as a calculator but please do not use it to assist with matrix multiplication. **As compensation, you will receive a $15 Amazon gift card.** Note that you must meet a minimum precalculated survey statistic to receive the compensation.

This survey has been approved by the Georgia Institute of Technology IRB. We recommend that you conduct this survey on your computer rather than on a mobile device.

Pairwise Decision Tree Introduction

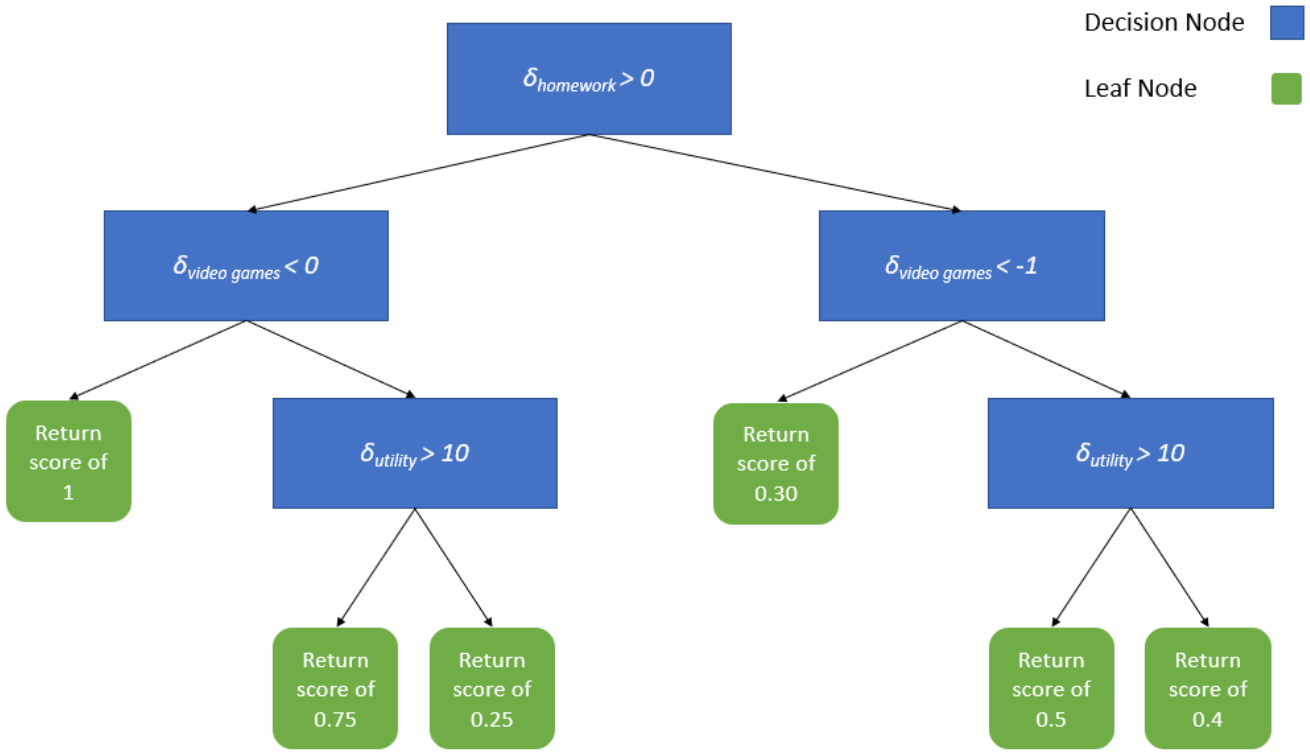
A pairwise decision tree is is decision-making model in which each internal node represents a “test” on an attribute (e.g. how much more homework person A completed than person B), each branch represents the outcome of the test, and each leaf node represents a **score for the difference of inputs** (e.g., how much higher person A's test grade is compared to person B). The paths from root to leaf represent classification rules.

In our trees, moving LEFT in the decision tree is associated a "test" of an attribute being true.

Let's do a quick example.

Please pay attention as you will not be allowed to come back and view this page.

Pairwise Decision Tree representing the decision score of "How much do you prefer person A compared to person B?".



In the decision tree above, the input into the decision tree would be a **set** of [How much homework does the person do?, How many video games does the person

play?, What is the utility of the person?]. To generate the decision tree input, we would subtract the traits of the first person from the second. Then, using this as the input to the decision tree, we can find a difference score for how much the first person is preferred compared to the second.

For example,

Say you are given three inputs,
Person 1: [Homework = 10, Video Games = 3, Utility = 1],
Person 2: [Homework = 3, Video Games = 4, Utility = 0],
Person 3: [Homework = 14, Video Games = 3, Utility = 14].

There are 6 combinations of subtracted vectors: (Person 1 - Person 3), (Person 2 - Person 3), (Person 3 - Person 1), (Person 3 - Person 2), (Person 1 - Person 2), and (Person 2 - Person 1).

Person 1 - Person 2 = [10, 3, 1] - [3, 4, 0] = [7, -1, 1]. Putting this through the decision tree generates a score of 1.

These can be put into a matrix form, where the element being subtracted from is the row, and the subtractor is the column.

$$\begin{bmatrix} 0 & \text{Person 1 - Person 2} & \text{Person 1 - Person 3} \\ \text{Person 2 - Person 1} & 0 & \text{Person 2 - Person 3} \\ \text{Person 3 - Person 1} & \text{Person 3 - Person2} & 0 \end{bmatrix}$$

Plugging in each subtracted pair into the decision tree above will produce this matrix.

$$\begin{bmatrix} 0 & 1 & 0.4 \\ 0.4 & 0 & 0.4 \\ 0.75 & 1 & 0 \end{bmatrix}$$

Then, we can sum across columns to get the score for each person , respectively.

$$\begin{bmatrix} \text{Person 1} \\ \text{Person 2} \\ \text{Person 3} \end{bmatrix} = \begin{bmatrix} 1.4 \\ 0.8 \\ 1.75 \end{bmatrix}$$

Since Person C has the highest score, we choose person C.

On the next page, you will be given a decision tree representing scheduling behavior. Given input data about the difficulty of three tasks and whether the scheduler prefers to handle difficult tasks or easy tasks, you will have to use the decision tree given to decide which task to schedule.

The input array will be of size 3, and the decision tree will reference the corresponding element using {#} notation.

For example, for the input data of [11, 22, 33, 44, 55], {3} refers to 33.

Pairwise Decision Tree Test

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#EditSection, TimingClickCount#: *0 clicks*

Input data:

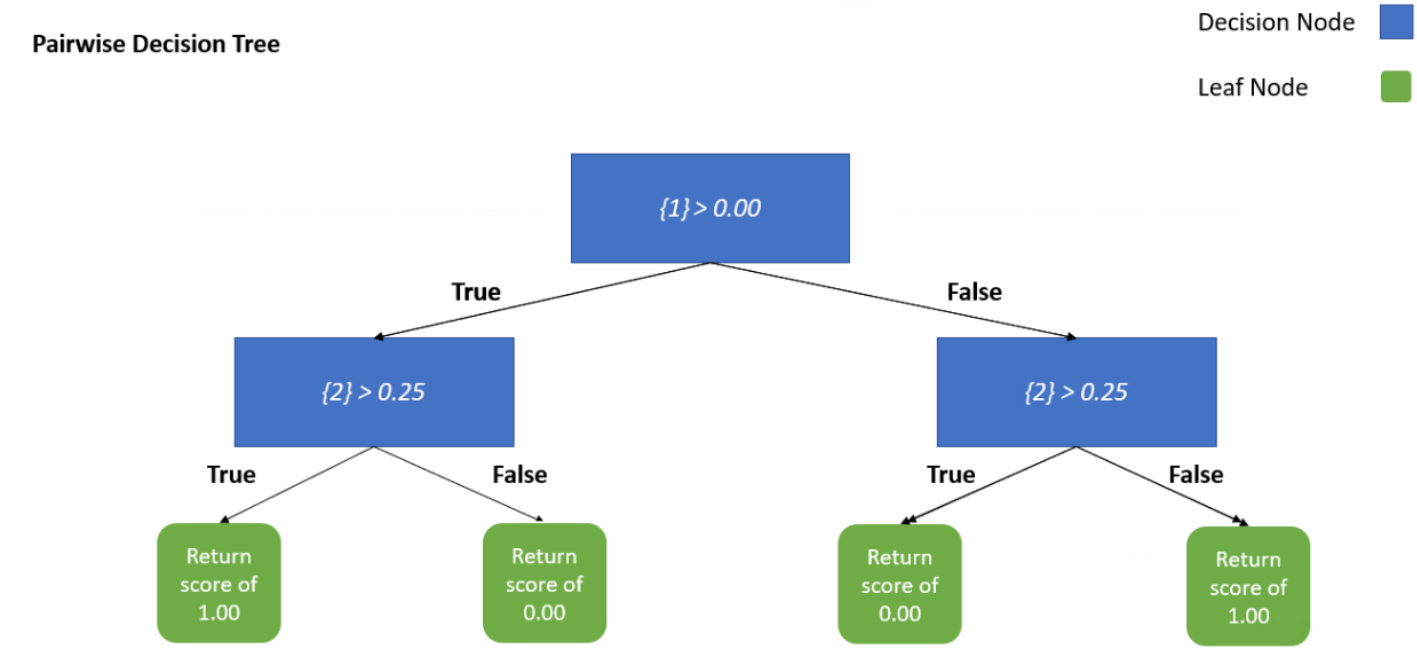
Task 1: [3]
Task 2: [2]
Task 3: [1]

{2} is fixed to 0.4,

Clarification: To compute the input feature {1} for (Task 1 - Task 2), we would subtract Task 1 - Task 2. {2} is fixed to 0.4.

The instructions from the previous page are found at the bottom of this page. Note that the previous page used Person 1, Person 2, and Person 3 and here we use Task 1, Task 2, and Task 3.

Pairwise decision tree representing scheduling behavior.



Please write down the difference vectors (in the format [#]). For example, if task 5 had data of [4], and task 6 had data of [3], task 5 - task 6 is equal to [1].

Task 1 - Task 2

Task 1 - Task 3

Task 2 - Task 1

Task 2 - Task 3

Task 3 - Task 1

Task 3 - Task 2

Please fill in the fields below.

	Task 1	Task 2	Task 3
Task 1			
Task 2			
Task 3			

Please write the scores below.

Task 1 Score

Task 2 Score

Task 3 Score

What is the output of this decision tree given the input above? Please type the number of the task. In the case of ties, break ties using numerical order.

For example, if the output you receive is Task 5 has the highest score, you would type 5.

Instructions

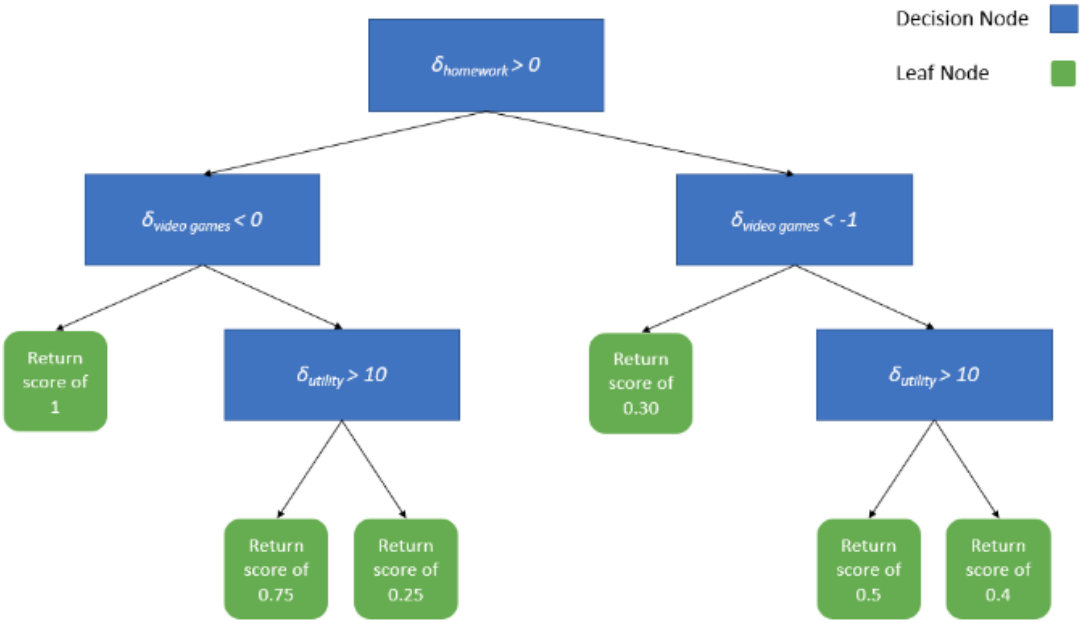
A pairwise decision tree is is decision-making model in which each internal node represents a “test” on an attribute (e.g. how much more homework person A completed than person B), each branch represents the outcome of the test, and each leaf node represents a **score for the difference of inputs** (e.g., how much higher person A's test grade is compared to person B). The paths from root to leaf represent classification rules.

In our trees, moving LEFT in the decision tree is associated a "test" of an attribute being true.

Let's do a quick example.

Please pay attention as you will not be allowed to come back and view this page.

Pairwise Decision Tree representing the decision score of "How much do you prefer person A compared to person B?".



In the decision tree above, the input into the decision tree would be a **set** of [How much homework does the person do?, How many video games does the person play?, What is the utility of the person?]. To generate the decision tree input, we would subtract the traits of the first person from the second. Then, using this as the input to the decision tree, we can find a difference score for how much the first person is preferred compared to the second.

For example,

Say you are given three inputs,
Person 1: [Homework = 10, Video Games = 3, Utility = 1],
Person 2: [Homework = 3, Video Games = 4, Utility = 0],
Person 3: [Homework = 14, Video Games = 3, Utility = 14].

There are 6 combinations of subtracted vectors: (Person 1 - Person 3), (Person 2 - Person 3), (Person 3 - Person 1), (Person 3 - Person 2), (Person 1 - Person 2), and (Person 2 - Person 1).

Person 1 - Person 2 = [10, 3, 1] - [3, 4, 0] = [7, -1, 1]. Putting this through the decision tree generates a score of 1.

These can be put into a matrix form, where the element being subtracted from is the row, and the subtractor is the column.

$$\begin{bmatrix} 0 & \text{Person 1 - Person 2} & \text{Person 1 - Person 3} \\ \text{Person 2 - Person 1} & 0 & \text{Person 2 - Person 3} \\ \text{Person 3 - Person 1} & \text{Person 3 - Person2} & 0 \end{bmatrix}$$

Plugging in each subtracted pair into the decision tree above will produce this matrix.

$$\begin{bmatrix} 0 & 1 & 0.4 \\ 0.4 & 0 & 0.4 \\ 0.75 & 1 & 0 \end{bmatrix}$$

Then, we can sum across columns to get the score for each person , respectively.

$$\begin{bmatrix} \text{Person 1} \\ \text{Person 2} \\ \text{Person 3} \end{bmatrix} = \begin{bmatrix} 1.4 \\ 0.8 \\ 1.75 \end{bmatrix}$$

Since Person C has the highest score, we choose person C.

On the next page, you will be given a decision tree representing scheduling behavior. Given input data about the difficulty of three tasks and whether the scheduler prefers to handle difficult tasks or easy tasks, you will have to use the decision tree given to decide which task to schedule.

The input array will be of size 3, and the decision tree will reference the corresponding element using {#} notation.

For example, for the input data of [11, 22, 33, 44, 55], {3} refers to 33.

Pairwise Decision Tree Survey

Please fill out the questions below. The phrase "decision-making model" refers specifically to the graphic on the previous page. The phrase overall "decision-making process" refers to the entire process starting from being given input(s) to answering the question(s).

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model is interpretable.	○	○	○	○	○	○	○
I understand the behavior represented within the decision-making model.	○	○	○	○	○	○	○
The decision-making model logic is easy to follow.	○	○	○	○	○	○	○
The decision-making model does not make sense.	○	○	○	○	○	○	○
The decision-making model is difficult to understand.	○	○	○	○	○	○	○

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
I could follow the rules of this decision-making model with ease.	○	○	○	○	○	○	○
I like the level of readability of this decision-making model.	○	○	○	○	○	○	○
The overall decision-making process is easy to comprehend.	○	○	○	○	○	○	○
I understand the overall process of choosing an output given input(s).	○	○	○	○	○	○	○
This overall decision-making process logic is easy to follow.	○	○	○	○	○	○	○
The overall decision-making process does not make sense.	○	○	○	○	○	○	○
The overall decision-making process is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making tool with ease.	○	○	○	○	○	○	○

Pairwise Neural Network Introduction

Here, we introduce pairwise neural networks.

Please pay attention as you will not be allowed to come back and view this page.

In the neural network below, the input into the neural network would be a **set** of the input features [How much homework does the person do?, How many video games does the person play?, What is the work rate of the person?]. To generate the neural

network input, we would subtract the traits of the first person from the second. Then, using this as the input to the neural network, we can find a difference score for how much the first person is preferred to the second.

For example,

Say you are given three inputs,
Person 1: [Homework = 10, Video Games = 3, Utility = 1],
Person 2: [Homework = 3, Video Games = 4, Utility = 0],
Person 3: [Homework = 14, Video Games = 3, Utility = 14].

There are 6 combinations of subtracted vectors that will serve as input into the neural network: (Person 1 - Person 3), (Person 2 - Person 3), (Person 3 - Person 1), (Person 3 - Person 2), (Person 1 - Person 2), and (Person 2 - Person 1).

Person 1 - Person 2 = [10, 3, 1] - [3, 4, 0] = [7, -1, 1].
Person 1 - Person 3 = [10, 3, 1] - [14, 3, 14] = [-4, 0, -13]
and so on.

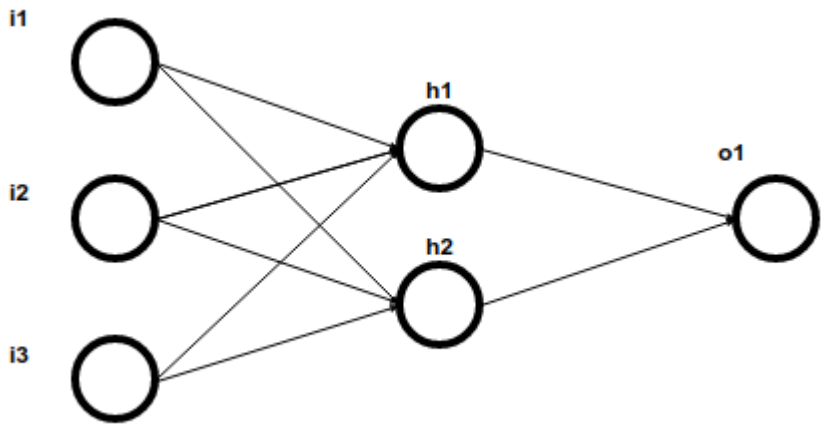
We can find the output of our network in matrix form using the equations, where the input, x, is the subtracted vectors described above:
$H = W_1 * x + B_1$
$H = ReLU(H)$
$O = W_2 * H + B_2$

$$W_1 = \begin{matrix} \\ h1 \\ h2 \end{matrix} \begin{matrix} i1 & i2 & i3 \\ \end{matrix} \begin{bmatrix} 1 & 0 & 1 \\ 3 & 0 & 2 \end{bmatrix}$$

$$B_1 = \begin{matrix} b1 \\ b2 \end{matrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$W_2 = \begin{matrix} \\ o1 \end{matrix} \begin{matrix} h1 & h2 \\ \end{matrix} \begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$B_2 = \begin{matrix} b1 \end{matrix} \begin{bmatrix} 1 \end{bmatrix}$$



Computing the output of Person 1 - Person 2 = [10, 3, 1] - [3, 4, 0] = [7, -1, 1]:

To get to value of h1, we do (7 * 1 + -1 * 0 + 1 * 1) + 0 = 8
To get to value of h2, we do (7 * 3 + -1 * 0 + 1 * 2) + 1 = 24

Now we apply the ReLU activation function to h1 and h2 (shown below). Simply, this function transforms any number below 0 to 0, and any other number stays the same. Since h1 and h2 are positive, they remain unchanged.

To find o1, we do (8 * 0 + 24 * 1) + 1 = 25 to get the value score of o1.

We can do this for each input and put the outputs into the following matrix form.

$$\begin{bmatrix} 0 & \text{Person 1 - Person 2} & \text{Person 1 - Person 3} \\ \text{Person 2 - Person 1} & 0 & \text{Person 2 - Person 3} \\ \text{Person 3 - Person 1} & \text{Person 3 - Person2} & 0 \end{bmatrix}$$

The final output matrix is then

$$\begin{bmatrix} 0 & 25 & 0 \\ 0 & 0 & 0 \\ 40 & 63 & 0 \end{bmatrix}$$

Then, we can sum across columns to get the score for each person , respectively.

$$\begin{bmatrix} \text{Person 1} \\ \text{Person 2} \\ \text{Person 3} \end{bmatrix} = \begin{bmatrix} 25 \\ 0 \\ 103 \end{bmatrix}$$

Since Person C has the highest score, we choose person C.

On the next page, you will be given a neural network representing scheduling behavior. Given input data about three tasks, you will have to use the neural network given to decide which task to schedule.

The input array will be of size 2. i1 will correspond to the first element, and so forth.

For example, for the input data of [11, 22, 33, 44, 55, 66, 77], i4 corresponds to 44.

Pairwise Neural Network Test

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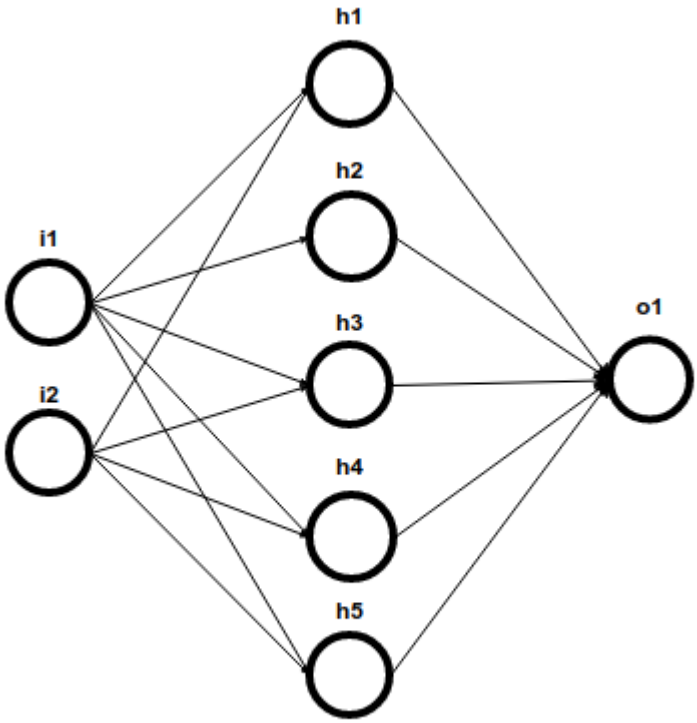
Input data:

Task 1: [1]
Task 2: [2]
Task 3: [3]

Clarification: To compute the input feature for (Task 1 - Task 2), we would subtract Task 1 - Task 2 to get i1. i2 is fixed to the values mentioned below.

The instructions found on the previous page are attached at the end of this page for reference.

Pairwise neural network representing scheduling behavior. A ReLU is applied after the first layer.



i2 is fixed to 1.

$$\begin{array}{c} \\ h1 \\ h2 \\ h3 \\ h4 \\ h5 \end{array} \begin{array}{c} \begin{array}{cc} i1 & i2 \end{array} \\ \begin{bmatrix} 0.25 & -0.5 \\ -0.25 & -1.5 \\ 0 & -0.5 \\ -0.5 & -2.25 \\ 0.5 & 2.50 \end{bmatrix} \end{array}$$

$$\begin{array}{c} \\ b1 \\ b2 \\ b3 \\ b4 \\ b5 \end{array} \begin{array}{c} \\ \begin{bmatrix} -0.5 \\ 0.5 \\ 0 \\ 0.75 \\ -1.5 \end{bmatrix} \end{array}$$

$$\begin{array}{c} \\ o1 \end{array} \begin{array}{c} \begin{array}{ccccc} j1 & j2 & j3 & j4 & j5 \end{array} \\ \begin{bmatrix} 0.25 & 1.75 & -0.25 & 2.75 & 2 \end{bmatrix} \end{array}$$

$$\begin{array}{c} \\ b1 \end{array} \begin{array}{c} \\ \begin{bmatrix} -1.5 \end{bmatrix} \end{array}$$

Please write down the difference vectors (in the format [#]). For example, if task 5 had data of [4], and task 6 had data of [3], task 5 - task 6 is equal to [1].

Task 1 - Task 2	
Task 1 - Task 3	
Task 2 - Task 1	
Task 2 - Task 3	
Task 3 - Task 1	
Task 3 - Task 2	

Please fill out the fields below.

	Task 1	Task 2	Task 3
Task 1			
Task 2			
Task 3			

Please write the final scores below.

Task 1 Score	
Task 2 Score	
Task 3 Score	

What is the output of this neural network given the input above? Please type the number of the task. In the case of ties, break ties using numerical order.

For example, if the output you receive is task 5 has the highest score, you would type 5.

Here are the instructions for reference.

Here, we introduce pairwise neural networks.

Please pay attention as you will not be allowed to come back and view this page.

In the neural network below, the input into the neural network would be a **set** of the input features [How much homework does the person do?, How many video games does the person play?, What is the work rate of the person?]. To generate the decision tree input, we would subtract the traits of the first person from the second. Then, using this as the input to the decision tree, we can find a difference score for how much the first person is preferred to the second.

For example,

Say you are given three inputs,
Person 1: [Homework = 10, Video Games = 3, Utility = 1],
Person 2: [Homework = 3, Video Games = 4, Utility = 0],
Person 3: [Homework = 14, Video Games = 3, Utility = 14].

There are 6 combinations of subtracted vectors that will serve as input into the neural network: (Person 1 - Person 3), (Person 2 - Person 3), (Person 3 - Person 1), (Person 3 - Person 2), (Person 1 - Person 2), and (Person 2 - Person 1).

Person 1 - Person 2 = [10, 3, 1] - [3, 4, 0] = [7, -1, 1].
Person 1 - Person 3 = [10, 3, 1] - [14, 3, 14] = [-4, 0, -13]
and so on.

We can find the output of our network in matrix form using the equations:

H = W_1 * x + B_1

H = ReLU(H)

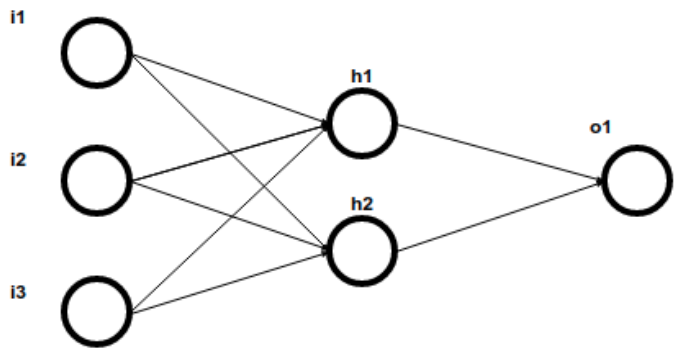
O = W_2 * H + B_2

$$W_1 = \begin{matrix} \\ h1 \\ h2 \end{matrix} \begin{matrix} i1 & i2 & i3 \\ \end{matrix} \begin{bmatrix} 1 & 0 & 1 \\ 3 & 0 & 2 \end{bmatrix}$$

$$B_1 = \begin{matrix} b1 \\ b2 \end{matrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$W_2 = \begin{matrix} \\ o1 \end{matrix} \begin{matrix} h1 & h2 \\ \end{matrix} \begin{bmatrix} 0 & 1 \end{bmatrix}$$

$$B_2 = \begin{matrix} b1 \end{matrix} \begin{bmatrix} 1 \end{bmatrix}$$



Computing the output of Person 1 - Person 2 = [10, 3, 1] - [3, 4, 0] = [7, -1, 1].

To get to value of h1, we do (7 * 1 + -1 * 0 + 1 * 1) + 0 = 8
To get to value of h2, we do (7 * 3 + -1 * 0 + 1 * 2) + 1 = 24

Now we apply the ReLU activation function to h1 and h2 (shown below). Simply, this function transforms any number below 0 to 0, and any other number stays the same. Since h1 and h2 are positive, they remain unchanged.

To find o1, we do (8 * 0 + 24 * 1) + 1 = 25 to get the value score of o1.

We can do this for each input and put the outputs into the following matrix form.

$$\begin{bmatrix} 0 & \text{Person 1 - Person 2} & \text{Person 1 - Person 3} \\ \text{Person 2 - Person 1} & 0 & \text{Person 2 - Person 3} \\ \text{Person 3 - Person 1} & \text{Person 3 - Person2} & 0 \end{bmatrix}$$

The final output matrix is then

$$\begin{bmatrix} 0 & 25 & 0 \\ 0 & 0 & 0 \\ 40 & 63 & 0 \end{bmatrix}$$

Then, we can sum across columns to get the score for each person , respectively.

$$\begin{bmatrix} \text{Person 1} \\ \text{Person 2} \\ \text{Person 3} \end{bmatrix} = \begin{bmatrix} 25 \\ 0 \\ 103 \end{bmatrix}$$

Since Person C has the highest score, we choose person C.

On the next page, you will be given a neural network representing scheduling behavior. Given input data about three tasks, you will have to use the neural network given to decide which task to schedule.

The input array will be of size 5. i1 will correspond to the first element, and so forth.

For example, for the input data of [11, 22, 33, 44, 55, 66, 77], i4 corresponds to 44.

Pairwise Neural Network Survey

Please fill out the questions below. The phrase "decision-making model" refers specifically to the graphic on the previous page. The phrase overall "decision-making process" refers to the entire process starting from being given input(s) to answering the question(s).

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model is interpretable.	○	○	○	○	○	○	○
I understand the behavior represented within the decision-making model.	○	○	○	○	○	○	○
The decision-making model logic is easy to follow.	○	○	○	○	○	○	○

	Very Strongly Disagree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Very Strongly Agree
The decision-making model does not make sense.	○	○	○	○	○	○	○
The decision-making model is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making model with ease.	○	○	○	○	○	○	○
I like the level of readability of this decision-making model.	○	○	○	○	○	○	○
The overall decision-making process is easy to comprehend.	○	○	○	○	○	○	○
I understand the overall process of choosing an output given input(s).	○	○	○	○	○	○	○
This overall decision-making process logic is easy to follow.	○	○	○	○	○	○	○
The overall decision-making process does not make sense.	○	○	○	○	○	○	○
The overall decision-making process is difficult to understand.	○	○	○	○	○	○	○
I could follow the rules of this decision-making tool with ease.	○	○	○	○	○	○	○

Conclusion

Thank you for agreeing to do this survey. Your response will help us generate interpretable decision-making models.

Please leave your email below and we will send you an Amazon gift card. If you have any further questions, please email Rohan Paleja at rpaleja3@gatech.edu.

Email Address

Comments on our survey?