

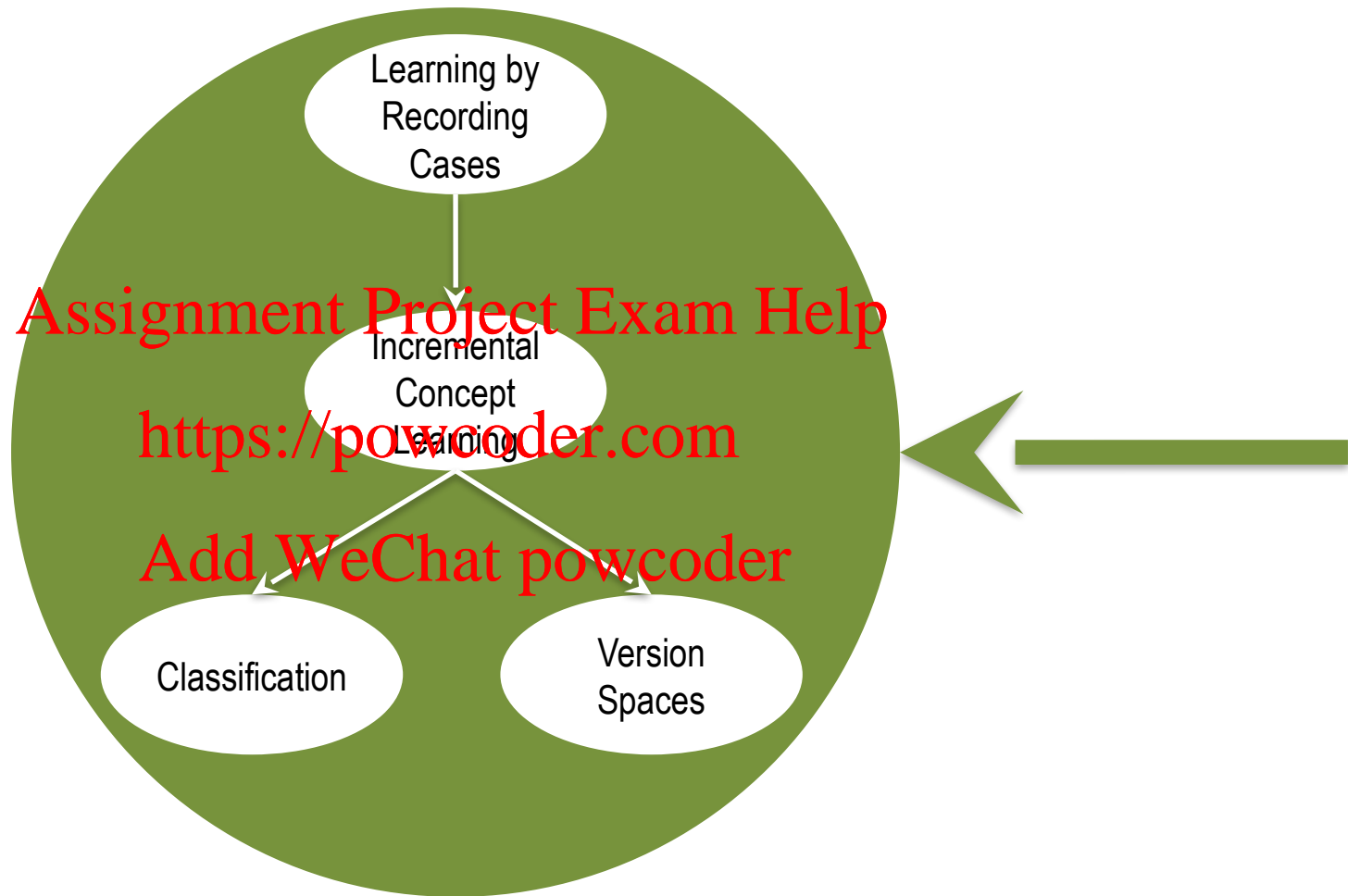
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Version
Spaces

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Learning



Lesson Preview

- Definition
- Abstract version spaces
- Algorithm for version spaces
- Identification trees

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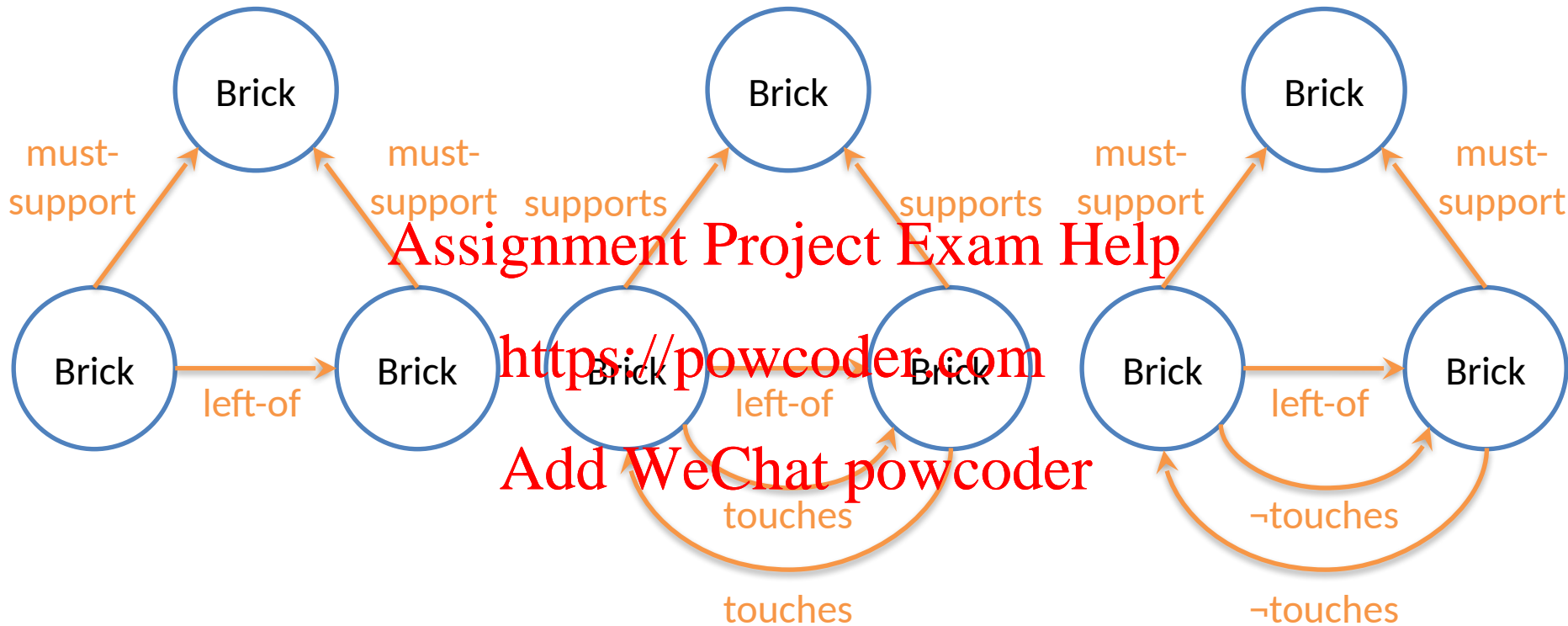
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Current Concept

Not an Arch

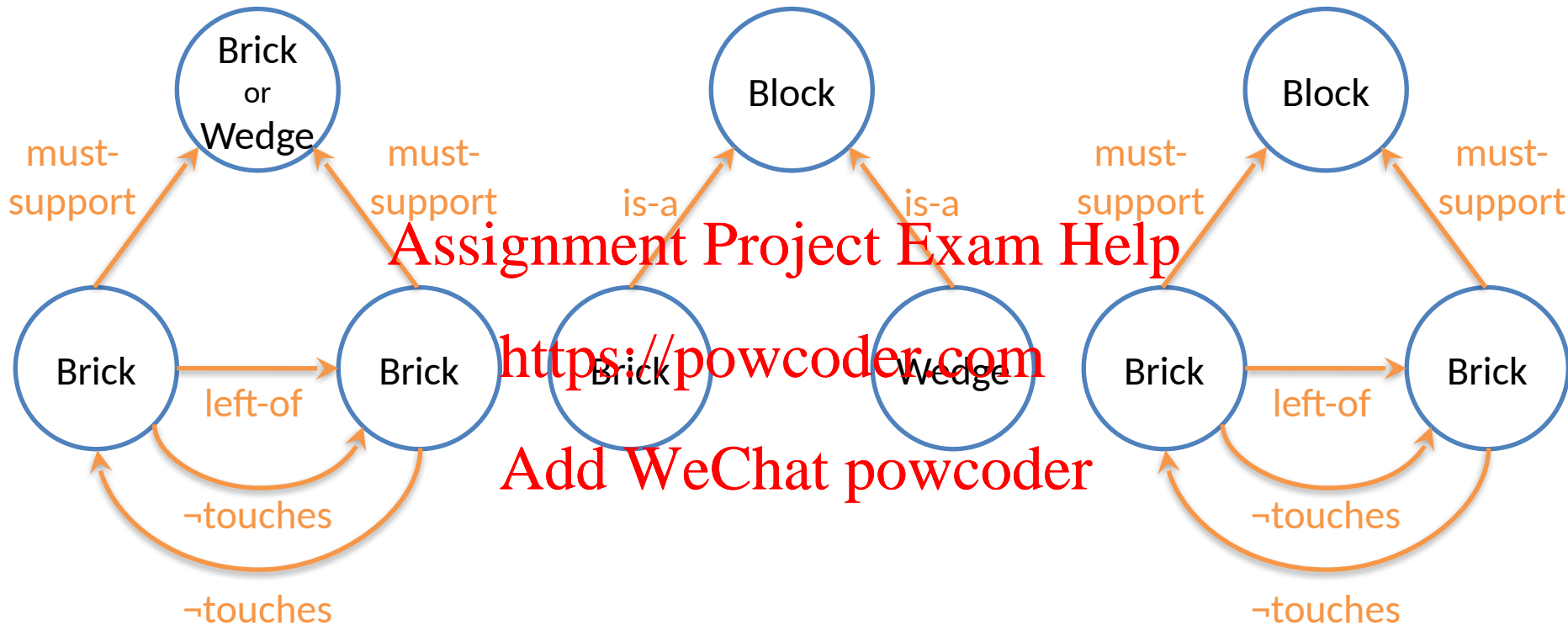
New Concept



Current Concept

Background Knowledge

Current Concept



Incremental Concept Learning

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Incremental Concept Learning

Example #1:

Positive

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Incremental Concept Learning

Example #1:

Positive

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Incremental Concept Learning

Example #2:

Negative

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Incremental Concept Learning

Example #2:

Negative

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Incremental Concept Learning

Example #3:

Negative

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Incremental Concept Learning

Example #3:

Negative

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Incremental Concept Learning

Example #4:

Positive

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Incremental Concept Learning

Example #4:

Positive

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Incremental Concept Learning

Example #5:

Negative

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Incremental Concept Learning

Example #5:

Negative

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Incremental Concept Learning

Example #6:

Negative

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Incremental Concept Learning

Example #6:

Negative

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Incremental Concept Learning

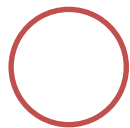
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Version Spaces



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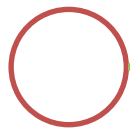
Specific

General

Version Spaces

Example #1:

Positive



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Specific



General

Version Spaces

Example #1:

Positive

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Version Spaces

Example #2:

Negative

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Version Spaces

Example #2:

Negative

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Version Spaces

Example #3:

Negative

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Version Spaces

Example #3:

Negative

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Version Spaces

Example #4:

Positive

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Version Spaces

Example #4:

Positive

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Version Spaces

Example #5:

Negative

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Version Spaces

Example #5:

Negative

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Version Spaces

Example #6:

Negative

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Version Spaces

Example #6:

Negative

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Version Spaces

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Incremental Concept Learning

Given new example:

Is this an example of the concept?

yes
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Generalize the
'specific' model

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Specialize the
'general' model

Most specific model
(matches one thing)

Most general model
(matches everything)

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Specific



General

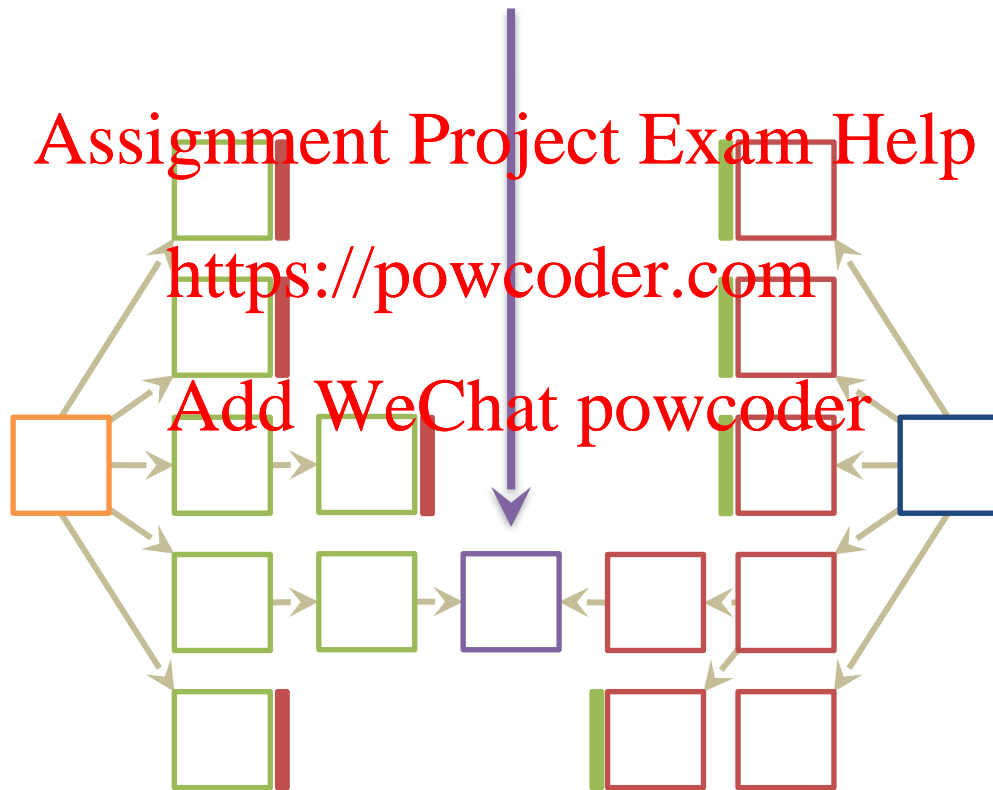
Positive and negative samples
force models to converge

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Specific



General

Number	Restaurant	Meal	Day	Cost	Allergic Reaction?
Visit1	Sam's	Breakfast	Friday	Cheap	Yes
Visit2	Kim's	Lunch	Friday	Expensive	No
Visit3	Sam's	Lunch	Saturday	Cheap	Yes
Visit4	Bob's	Breakfast	Sunday	Cheap	No
Visit5	Sam's	Breakfast	Sunday	Expensive	No

Visit1

restaurant :

Sam's

meal :

breakfast

day : Friday

cost : cheap

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Visit1

restaurant :

Sam's

meal :

breakfast

day : Friday

t : cheap

Sam's
breakfast
Friday
cheap

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[any]
[any]
[any]
[any]

Specific

General

Visit2

restaurant :

Kim's

meal : lunch

day : Friday

cost :

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Sam's
breakfast
Friday
cheap

[any]
[any]
[any]
[any]

Specific

General

Visit2

restaurant :

Kim's

meal : lunch

day : Friday

cost :

expensive

breakfast

Friday

cheap

[any]
Breakfast
[any]
[any]

[any]
[any]
Friday
[any]

Sam's
[any]
[any]
[any]

[any]
[any]
[any]
[any]

[any]
[any]
[any]
cheap

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Specific

General

Visit2

restaurant :

Kim's

meal : lunch

day : Friday

cost :

expensive

breakfast

Friday

cheap

[any]
Breakfast
[any]
[any]

[any]

[any]
[any]

Sam's
[any]
[any]
[any]

[any]
[any]
[any]
[any]

[any]
[any]
[any]
cheap

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Specific

General

Visit2

restaurant :

Kim's

meal : lunch

day : Friday

cost :

expensive

breakfast

Friday

cheap

[any]

Breakfast

[any]

[any]

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

cheap

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Specific

General

Visit3

restaurant :

Sam's

meal : lunch

day :

Saturday

cost : cheap

breakfast

Friday

cheap

[any]
Breakfast
[any]
[any]

Sam's
[any]
[any]
[any]

[any]
[any]
[any]
cheap

[any]
[any]
[any]
[any]

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Specific

General

Visit3

restaurant :

Sam's

meal : lunch

day :

Saturday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

[any]
Breakfast
[any]
[any]

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

cheap

Specific

General

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Add WeChat powcoder

Visit3

restaurant :

Sam's

meal : lunch

day :

Saturday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

[any]
~~Breakfast~~
[any]
[any]

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

cheap

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Add WeChat powcoder

Specific

General

Visit3

restaurant :

Sam's

meal : lunch

day :

Saturday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

cheap

Specific

General

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Add WeChat powcoder

Visit4

restaurant :

Bob's

meal :

Breakfast

day : Sunday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

[any]

cheap

Specific

General

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Add WeChat powcoder

Visit4

restaurant :

Bob's

meal :

Breakfast

day : Sunday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

Sam's

[any]

[any]

cheap

[any]

[any]

[any]

cheap

Specific

General

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Add WeChat powcoder

Visit4

restaurant :

Bob's

meal :

Breakfast

day : Sunday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

Sam's

[any]

[any]

cheap

[any]

[any]

[any]

cheap

Specific

General

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Add WeChat powcoder

Visit4

restaurant :

Bob's

meal :

Breakfast

day : Sunday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

Sam's



cheap

[any]



cheap

Specific

General

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Add WeChat powcoder

Visit4

restaurant :

Bob's

meal :

Breakfast

day : Sunday

Sam's cost

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

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Add WeChat powcoder

Specific

General

Visit5

restaurant :

Sam's

meal :

Breakfast

day : Sunday

Sam's cost

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

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Add WeChat powcoder

Specific

General

Visit5

restaurant :

Sam's

meal :

Breakfast

day : Sunday

Sam's cost

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

Specific

General

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Add WeChat powcoder

Visit5

restaurant :

Sam's

meal :

Breakfast

day : Sunday

Sam's

breakfast

Friday

cheap

Sam's

[any]

[any]

cheap

Sam's

Sam's

[any]

[any]

cheap

Sam's

[any]

[any]

[any]

[any]

[any]

[any]

[any]

Specific

General

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Add WeChat powcoder

Algorithm for Version Spaces

For each example:

If the example is **positive**:

Generalize all **specific** models to include it

Prune away **general** models that cannot include

it

If the example is **negative**:

Specialize all **general** models to include it

Prune away **specific** models that cannot

include it

Prune away any models **subsumed** by other models

Number	Meal	Meal	Day	Cost	Vegan	Reaction ?
Visit1	Kim's	Breakfast	Friday	Cheap	No	Yes
Visit2	Kim's	Lunch	Friday	Cheap	No	Yes
Visit3	Sam's	Lunch	Saturday	Cheap	No	No
Visit4	Kim's	Breakfast	Sunday	Cheap	Yes	No
Visit5	Sam's	Breakfast	Sunday	Expensive	Yes	No
Visit6	Kim's	Lunch	Saturday	Cheap	No	Yes

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What model did you converge on?

Kim's	[any]	[any]	Kim's	Kim's	[any]
[any]	[any]	Lunch	Lunch	[any]	[any]
[any]	[any]	Friday	Friday	[any]	[any]
Cheap	[any]	[any]	Cheap	Cheap	Cheap
[any]	[any]	No	No	No	No

Visit1

restaurant : Kim's

meal : Breakfast

day : Friday

cost : Cheap

vegan : no

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Kim's

Breakfast

Friday

Cheap

no

[any]

[any]

[any]

[any]

[any]

What would the initial general and specific models be?

Visit2

restaurant : Kim's

meal : Lunch

day : Friday

cost : Cheap

vegan : no

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Kim's
Breakfast
Friday
Cheap
no

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[any]
[any]
[any]
[any]
[any]

Based on this example, would we generalize or specialize?

o Generalize

o Specialize

Visit2

restaurant : Kim's

meal : Lunch

day : Friday

cost : Cheap

vegan : no

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Kim's
Breakfast
Friday
Cheap
no



Kim's
[any]
Friday
Cheap
no

[any]
[any]
[any]
[any]
[any]

After generalizing, what will the general model be?

Visit3

restaurant : Sam's
day : Saturday
cost : Cheap
vegan : no

meal : Lunch

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Kim's
Breakfast
Friday
Cheap
no



Kim's
[any]
Friday
Cheap
no

[any]
[any]
[any]
[any]
[any]

Based on this example, would we generalize or specialize?

o Generalize

o Specialize

Visit3

restaurant : Sam's
day : Saturday
cost : Cheap
vegan : no

meal : Lunch

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Kim's
Breakfast
Friday
Cheap
no



Kim's
[any]
Friday
Cheap
no

[any]
[any]
[any]
[any]
[any]

How many potential general models will we have after specializing based on this case and pruning?

3

Visit3

restaurant : Sam's
day : Saturday
cost : Cheap
vegan : no

meal : Lunch

Kim's
[any]

[any]
[any]

[any]

Kim's
Breakfast
Friday
Cheap
no

Kim's
[any]
Friday
Cheap
no

[any]
Breakfast
[any]
[any]
[any]

[any]
[any]

Friday
[any]

[any]

[any]
[any]
[any]
[any]
[any]

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Number	Meal	Meal	Day	Cost	Vegan	Reaction ?
Visit1	Kim's	Breakfast	Friday	Cheap	No	Yes
Visit2	Kim's	Lunch	Friday	Cheap	No	Yes
Visit3	Sam's	Lunch	Saturday	Cheap	No	No
Visit4	Kim's	Breakfast	Sunday	Cheap	Yes	No
Visit5	Sam's	Breakfast	Sunday	Expensive	Yes	No
Visit6	Kim's	Lunch	Saturday	Cheap	No	Yes

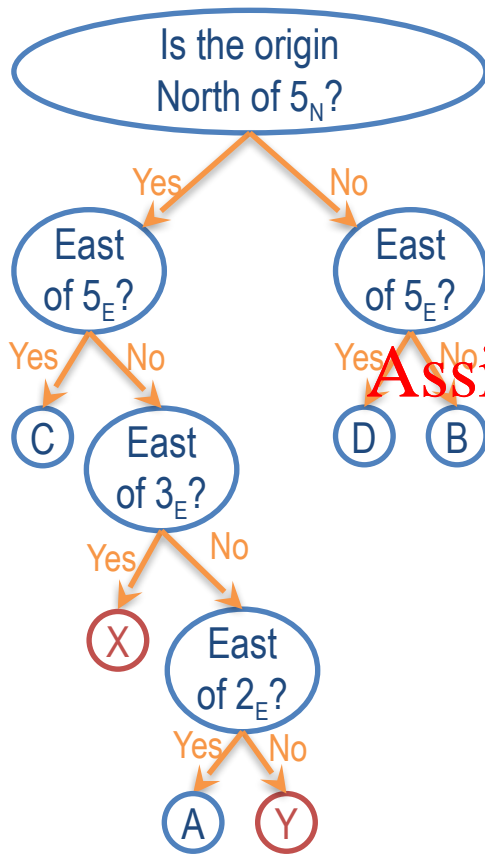
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What model did you converge on?

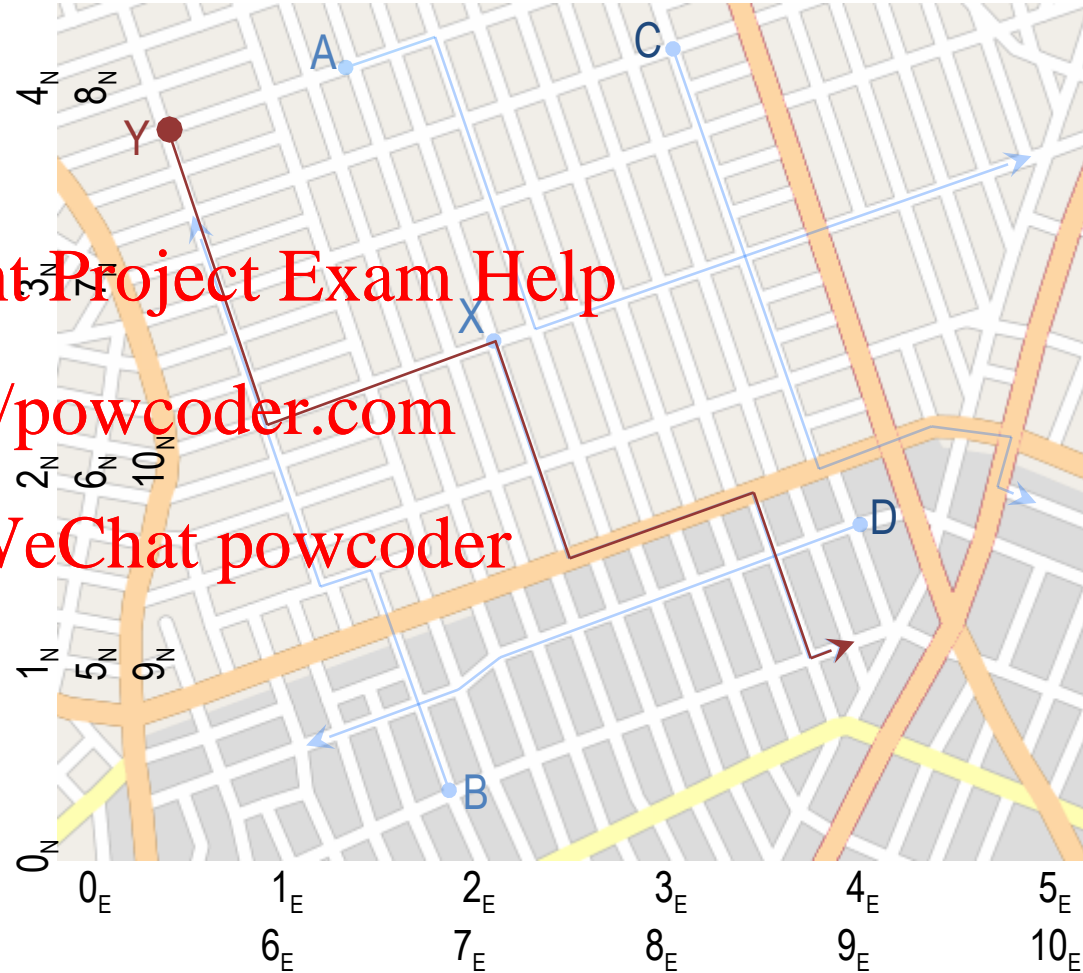
Kim's [any] [any] Cheap [any]	[any] [any] [any] [any] [any]	[any] Lunch Friday [any] No	Kim's Lunch Friday Cheap No	Kim's [any] [any] Cheap No	[any] [any] [any] Cheap No
---	---	---	---	--	--



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Number	Restaurant	Meal	Day	Cost	Allergic Reaction?
Visit1	Sam's	Breakfast	Friday	Cheap	Yes
Visit2	Kim's	Lunch	Friday	Expensive	No
Visit3	Sam's	Lunch	Saturday	Cheap	Yes
Visit4	Bob's	Breakfast	Sunday	Cheap	No
Visit5	Sam's	Breakfast	Sunday	Expensive	No

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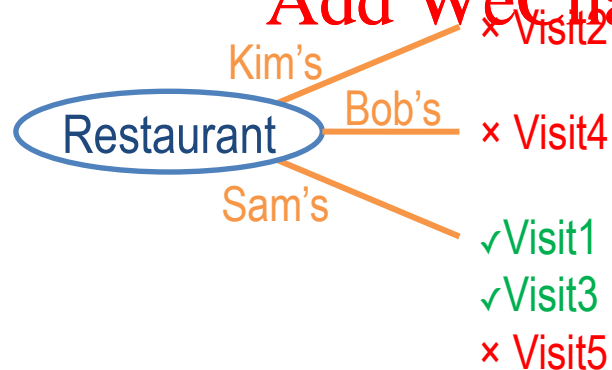
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Number	Restaurant	Meal	Day	Cost	Allergic Reaction?
Visit1	Sam's	Breakfast	Friday	Cheap	Yes
Visit2	Kim's	Lunch	Friday	Expensive	No
Visit3	Sam's	Lunch	Saturday	Cheap	Yes
Visit4	Bob's	Breakfast	Sunday	Cheap	No
Visit5	Sam's	Breakfast	Sunday	Expensive	No

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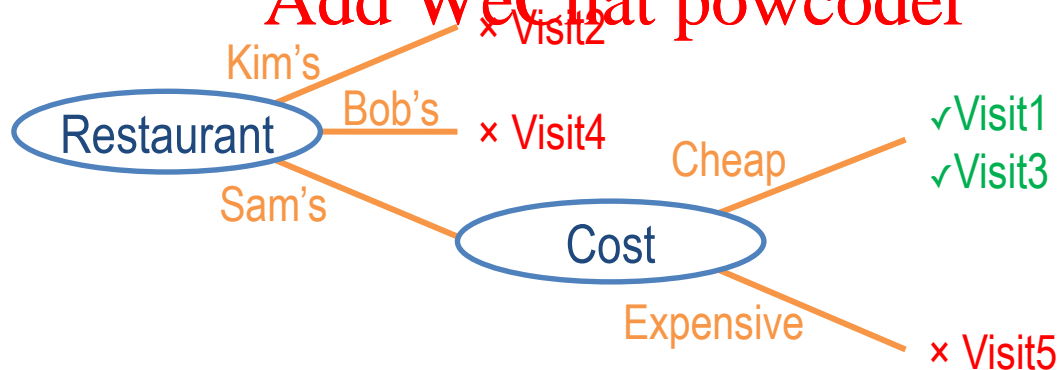


Number	Restaurant	Meal	Day	Cost	Allergic Reaction?
Visit1	Sam's	Breakfast	Friday	Cheap	Yes
Visit2	Kim's	Lunch	Friday	Expensive	No
Visit3	Sam's	Lunch	Saturday	Cheap	Yes
Visit4	Bob's	Breakfast	Sunday	Cheap	No
Visit5	Sam's	Breakfast	Sunday	Expensive	No

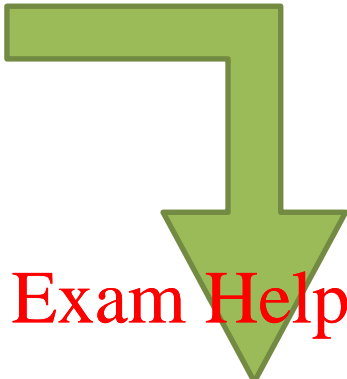
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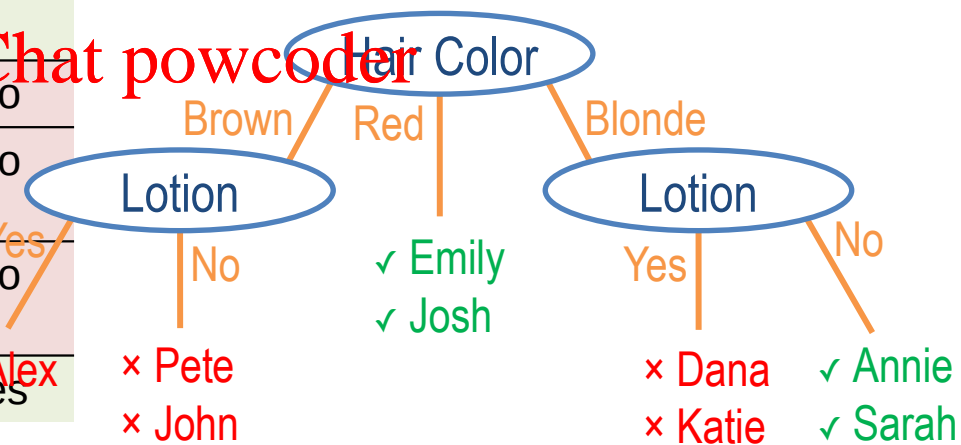
Name	Hair	Height	Age	Lotion	Burn ?
Sarah	Blonde	Average	20s	No	Yes
Dana	Blonde	Tall	30s	Yes	No
Alex	Brown	Short	30s	Yes	No
Annie	Blonde	Short	30s	No	Yes
Emily	Red	Average	40s	Yes	Yes
Pete	Brown	Tall	40s	No	No
John	Brown	Average	40s	No	No
Katie	Blonde	Short	20s	Yes	No
Josh	Red	Short	20s	No	Yes

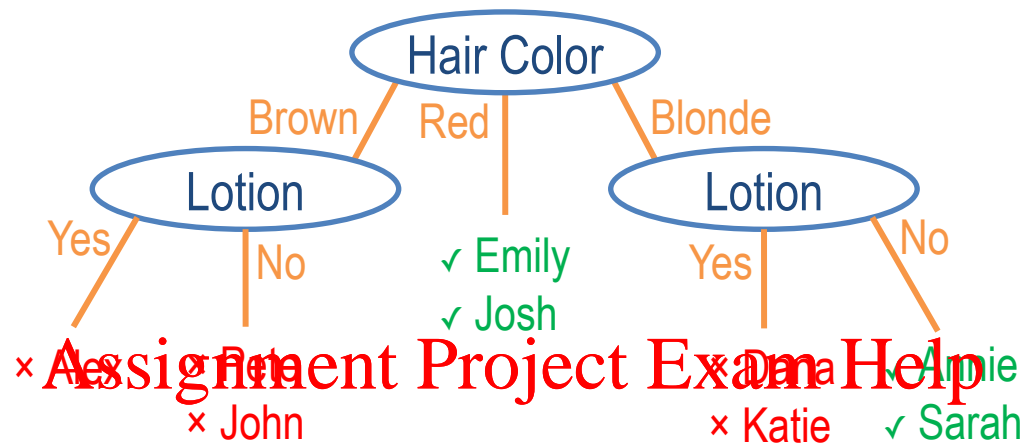


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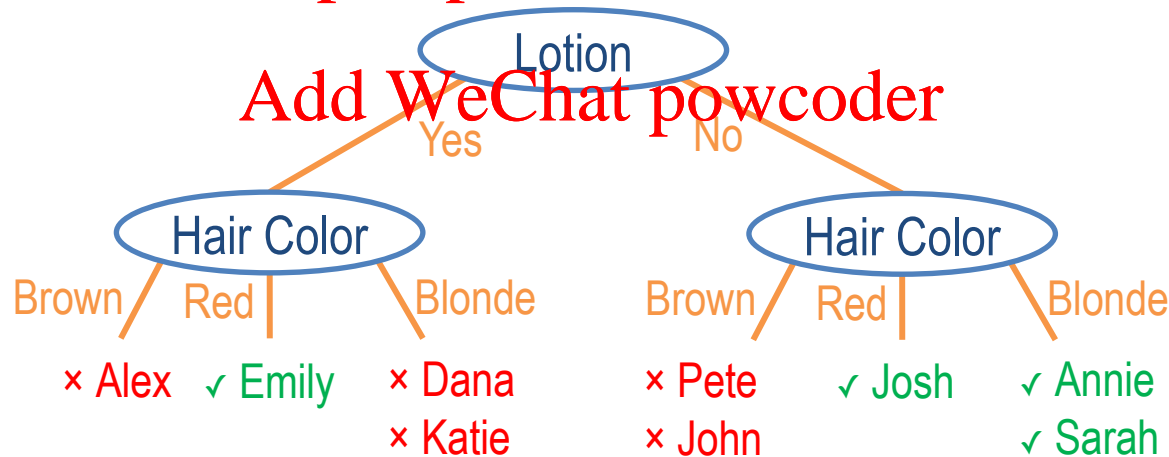
<https://powcoder.com>

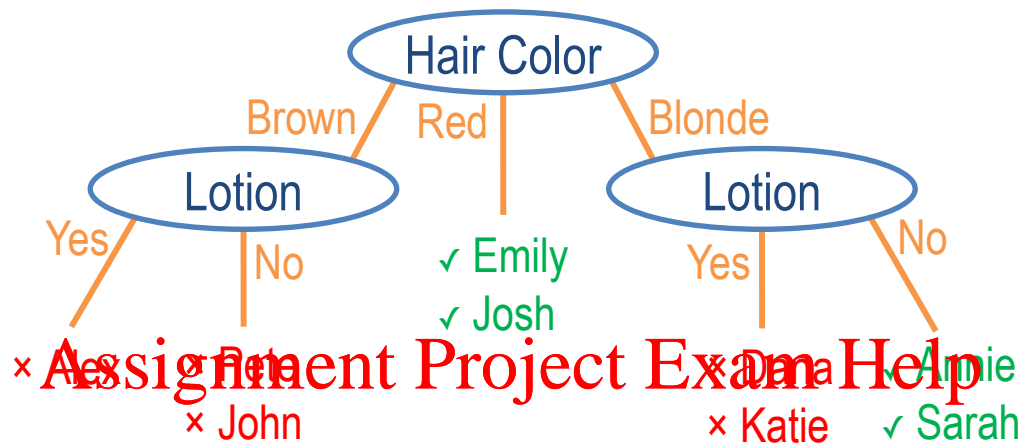
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Assignment

How would you use version spaces to design an agent that could answer Raven's progressive matrices?

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To recap...

- Definition of version spaces
- Algorithm for version spaces
- Complex problems with version spaces
- Limitations and questions
- Identification trees

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