

CS4445 A Term 2008 Homework 2 Solutions

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1 Prism Rule Generation

1.1 Rules for class=Iris-setosa

We start with all our initial instances:

sepalength	petalength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-long</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>

1.1.1 Rule 1

1.1.1.1 IF ? THEN **class=Iris-setosa**

We are starting with IF \emptyset THEN **class=Iris-setosa**, that is a rule with no antecedent. We can extend this rule in the following ways:

- (0.00% ; $\frac{0}{3}$) IF **sepalength=sl-long** THEN **class=Iris-setosa**
- (0.00% ; $\frac{0}{4}$) IF **sepalength=sl-med** THEN **class=Iris-setosa**
- (100.00% ; $\frac{3}{3}$) IF **sepalength=sl-short** THEN **class=Iris-setosa**
- (0.00% ; $\frac{0}{4}$) IF **petallength=pl-long** THEN **class=Iris-setosa**
- (0.00% ; $\frac{0}{3}$) IF **petallength=pl-med** THEN **class=Iris-setosa**
- (100.00% ; $\frac{3}{3}$) IF **petallength=pl-short** THEN **class=Iris-setosa**
- (0.00% ; $\frac{0}{2}$) IF **petalwidth=pw-long** THEN **class=Iris-setosa**
- (0.00% ; $\frac{0}{3}$) IF **petalwidth=pw-med** THEN **class=Iris-setosa**
- (100.00% ; $\frac{3}{3}$) IF **petalwidth=pw-short** THEN **class=Iris-setosa**

We see that our best choice is to add **sepalength=sl-short** to the rule making it cover 3 instance(s) with accuracy of 100.00%. The rule has 100% accuracy so we can stop here and add this rule to our ruleset.

We now remove all the instances covered by our new rule. We are left with:

sepalength	petallength	petalwidth	class
<i>sl-long</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>

There are no more instances with **class=Iris-setosa** so we are done with generating rules for this target class.

1.2 Rules for **class=Iris-versicolor**

We start with all our initial instances:

sepalength	petallength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-long</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>

1.2.1 Rule 1

1.2.1.1 IF ? THEN $\text{class}=\text{Iris-versicolor}$

We are starting with IF \emptyset THEN $\text{class}=\text{Iris-versicolor}$, that is a rule with no antecedent. We can extend this rule in the following ways:

- (66.67% ; $\frac{2}{3}$) IF $\text{sepalength}=\text{sl-long}$ THEN $\text{class}=\text{Iris-versicolor}$
- (50.00% ; $\frac{2}{4}$) IF $\text{sepalength}=\text{sl-med}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{3}$) IF $\text{sepalength}=\text{sl-short}$ THEN $\text{class}=\text{Iris-versicolor}$
- (25.00% ; $\frac{1}{4}$) IF $\text{petallength}=\text{pl-long}$ THEN $\text{class}=\text{Iris-versicolor}$
- (100.00% ; $\frac{3}{3}$) IF $\text{petallength}=\text{pl-med}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petallength}=\text{pl-short}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{2}$) IF $\text{petalwidth}=\text{pw-long}$ THEN $\text{class}=\text{Iris-versicolor}$
- (80.00% ; $\frac{4}{5}$) IF $\text{petalwidth}=\text{pw-med}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petalwidth}=\text{pw-short}$ THEN $\text{class}=\text{Iris-versicolor}$

We see that our best choice is to add $\text{petallength}=\text{pl-med}$ to the rule making it cover 3 instance(s) with accuracy of 100.00%. The rule has 100% accuracy so we can stop here and add this rule to our ruleset.

We now remove all the instances covered by our new rule. We are left with:

sepalength	petallength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>

1.2.2 Rule 2

1.2.2.1 IF ? THEN $\text{class}=\text{Iris-versicolor}$

We are starting with IF \emptyset THEN $\text{class}=\text{Iris-versicolor}$, that is a rule with no antecedent. We can extend this rule in the following ways:

- (50.00% ; $\frac{1}{2}$) IF $\text{sepalength}=\text{sl-long}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{2}$) IF $\text{sepalength}=\text{sl-med}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{3}$) IF $\text{sepalength}=\text{sl-short}$ THEN $\text{class}=\text{Iris-versicolor}$
- (25.00% ; $\frac{1}{4}$) IF $\text{petallength}=\text{pl-long}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{0}$) IF $\text{petallength}=\text{pl-med}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petallength}=\text{pl-short}$ THEN $\text{class}=\text{Iris-versicolor}$
- (0.00% ; $\frac{0}{2}$) IF $\text{petalwidth}=\text{pw-long}$ THEN $\text{class}=\text{Iris-versicolor}$

- (50.00% ; $\frac{1}{2}$) IF **petalwidth**=*pw-med* THEN **class**=*Iris-versicolor*
- (0.00% ; $\frac{0}{3}$) IF **petalwidth**=*pw-short* THEN **class**=*Iris-versicolor*

We see that our best choice is to add **sepalength**=*sl-long* to the rule making it cover 2 instance(s) with accuracy of 50.00%. Since the rule is not 100% accurate yet and we still have some attributes to extend the rule with, we continue.

1.2.2.2 IF **sepalength**=*sl-long* AND ? THEN **class**=*Iris-versicolor*

We are extending IF **sepalength**=*sl-long* THEN **class**=*Iris-versicolor*. We have the following options:

- (50.00% ; $\frac{1}{2}$) IF **sepalength**=*sl-long* AND **petallength**=*pl-long* THEN **class**=*Iris-versicolor*
- (0.00% ; $\frac{0}{0}$) IF **sepalength**=*sl-long* AND **petallength**=*pl-med* THEN **class**=*Iris-versicolor*
- (0.00% ; $\frac{0}{0}$) IF **sepalength**=*sl-long* AND **petallength**=*pl-short* THEN **class**=*Iris-versicolor*
- (0.00% ; $\frac{0}{1}$) IF **sepalength**=*sl-long* AND **petalwidth**=*pw-long* THEN **class**=*Iris-versicolor*
- (100.00% ; $\frac{1}{1}$) IF **sepalength**=*sl-long* AND **petalwidth**=*pw-med* THEN **class**=*Iris-versicolor*
- (0.00% ; $\frac{0}{0}$) IF **sepalength**=*sl-long* AND **petalwidth**=*pw-short* THEN **class**=*Iris-versicolor*

We see that our best choice is to add **petalwidth**=*pw-med* to the rule making it cover 1 instance(s) with accuracy of 100.00%. The rule has 100% accuracy so we can stop here and add this rule to our ruleset.

We now remove all the instances covered by our new rule. We are left with:

sepalength	petallength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>

There are no more instances with **class**=*Iris-versicolor* so we are done with generating rules for this target class.

1.3 Rules for **class**=*Iris-virginica*

We start with all our initial instances:

sepalength	petallength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-long</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-long</i>	<i>Iris-virginica</i>

1.3.1 Rule 1

1.3.1.1 IF ? THEN $\text{class}=\text{Iris-virginica}$

We are starting with IF \emptyset THEN $\text{class}=\text{Iris-virginica}$, that is a rule with no antecedent. We can extend this rule in the following ways:

- (33.33% ; $\frac{1}{3}$) IF $\text{sepallength}=\text{sl-long}$ THEN $\text{class}=\text{Iris-virginica}$
- (50.00% ; $\frac{2}{4}$) IF $\text{sepallength}=\text{sl-med}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{sepallength}=\text{sl-short}$ THEN $\text{class}=\text{Iris-virginica}$
- (75.00% ; $\frac{3}{4}$) IF $\text{petallength}=\text{pl-long}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petallength}=\text{pl-med}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petallength}=\text{pl-short}$ THEN $\text{class}=\text{Iris-virginica}$
- (100.00% ; $\frac{2}{2}$) IF $\text{petalwidth}=\text{pw-long}$ THEN $\text{class}=\text{Iris-virginica}$
- (20.00% ; $\frac{1}{5}$) IF $\text{petalwidth}=\text{pw-med}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petalwidth}=\text{pw-short}$ THEN $\text{class}=\text{Iris-virginica}$

We see that our best choice is to add $\text{petalwidth}=\text{pw-long}$ to the rule making it cover 2 instance(s) with accuracy of 100.00%. The rule has 100% accuracy so we can stop here and add this rule to our ruleset.

We now remove all the instances covered by our new rule. We are left with:

sepallength	petallength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-long</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-virginica</i>

1.3.2 Rule 2

1.3.2.1 IF ? THEN $\text{class}=\text{Iris-virginica}$

We are starting with IF \emptyset THEN $\text{class}=\text{Iris-virginica}$, that is a rule with no antecedent. We can extend this rule in the following ways:

- (0.00% ; $\frac{0}{2}$) IF $\text{sepallength}=\text{sl-long}$ THEN $\text{class}=\text{Iris-virginica}$
- (33.33% ; $\frac{1}{3}$) IF $\text{sepallength}=\text{sl-med}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{sepallength}=\text{sl-short}$ THEN $\text{class}=\text{Iris-virginica}$
- (50.00% ; $\frac{1}{2}$) IF $\text{petallength}=\text{pl-long}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petallength}=\text{pl-med}$ THEN $\text{class}=\text{Iris-virginica}$
- (0.00% ; $\frac{0}{3}$) IF $\text{petallength}=\text{pl-short}$ THEN $\text{class}=\text{Iris-virginica}$

- (0.00% ; $\frac{0}{0}$) IF **petalwidth**=*pw-long* THEN **class**=*Iris-virginica*
- (20.00% ; $\frac{1}{5}$) IF **petalwidth**=*pw-med* THEN **class**=*Iris-virginica*
- (0.00% ; $\frac{0}{3}$) IF **petalwidth**=*pw-short* THEN **class**=*Iris-virginica*

We see that our best choice is to add **petallength**=*pl-long* to the rule making it cover 2 instance(s) with accuracy of 50.00%. Since the rule is not 100% accurate yet and we still have some attributes to extend the rule with, we continue.

1.3.2.2 IF **petallength**=*pl-long* AND ? THEN **class**=*Iris-virginica*

We are extending IF **petallength**=*pl-long* THEN **class**=*Iris-virginica*. We have the following options:

- (0.00% ; $\frac{0}{1}$) IF **petallength**=*pl-long* AND **sepalength**=*sl-long* THEN **class**=*Iris-virginica*
- (100.00% ; $\frac{1}{1}$) IF **petallength**=*pl-long* AND **sepalength**=*sl-med* THEN **class**=*Iris-virginica*
- (0.00% ; $\frac{0}{0}$) IF **petallength**=*pl-long* AND **sepalength**=*sl-short* THEN **class**=*Iris-virginica*
- (0.00% ; $\frac{0}{0}$) IF **petallength**=*pl-long* AND **petalwidth**=*pw-long* THEN **class**=*Iris-virginica*
- (50.00% ; $\frac{1}{2}$) IF **petallength**=*pl-long* AND **petalwidth**=*pw-med* THEN **class**=*Iris-virginica*
- (0.00% ; $\frac{0}{0}$) IF **petallength**=*pl-long* AND **petalwidth**=*pw-short* THEN **class**=*Iris-virginica*

We see that our best choice is to add **sepalength**=*sl-med* to the rule making it cover 1 instance(s) with accuracy of 100.00%. The rule has 100% accuracy so we can stop here and add this rule to our ruleset.

We now remove all the instances covered by our new rule. We are left with:

sepalength	petallength	petalwidth	class
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-short</i>	<i>pl-short</i>	<i>pw-short</i>	<i>Iris-setosa</i>
<i>sl-long</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-long</i>	<i>pl-long</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>
<i>sl-med</i>	<i>pl-med</i>	<i>pw-med</i>	<i>Iris-versicolor</i>

There are no more instances with **class**=*Iris-virginica* so we are done with generating rules for this target class.

1.4 Final Ruleset

Having generated rules for each target class, we have the collected the following ruleset:

- IF **sepalength**=*sl-short* THEN **class**=*Iris-setosa*
- IF **petallength**=*pl-med* THEN **class**=*Iris-versicolor*
- IF **sepalength**=*sl-long* AND **petalwidth**=*pw-med* THEN **class**=*Iris-versicolor*
- IF **petalwidth**=*pw-long* THEN **class**=*Iris-virginica*
- IF **petallength**=*pl-long* AND **sepalength**=*sl-med* THEN **class**=*Iris-virginica*