Raptor – User Guide

Please Note: the guide has been produced with the intent to show users how to use Raptor, refer to the Input Guide for information about Raptor's syntax.
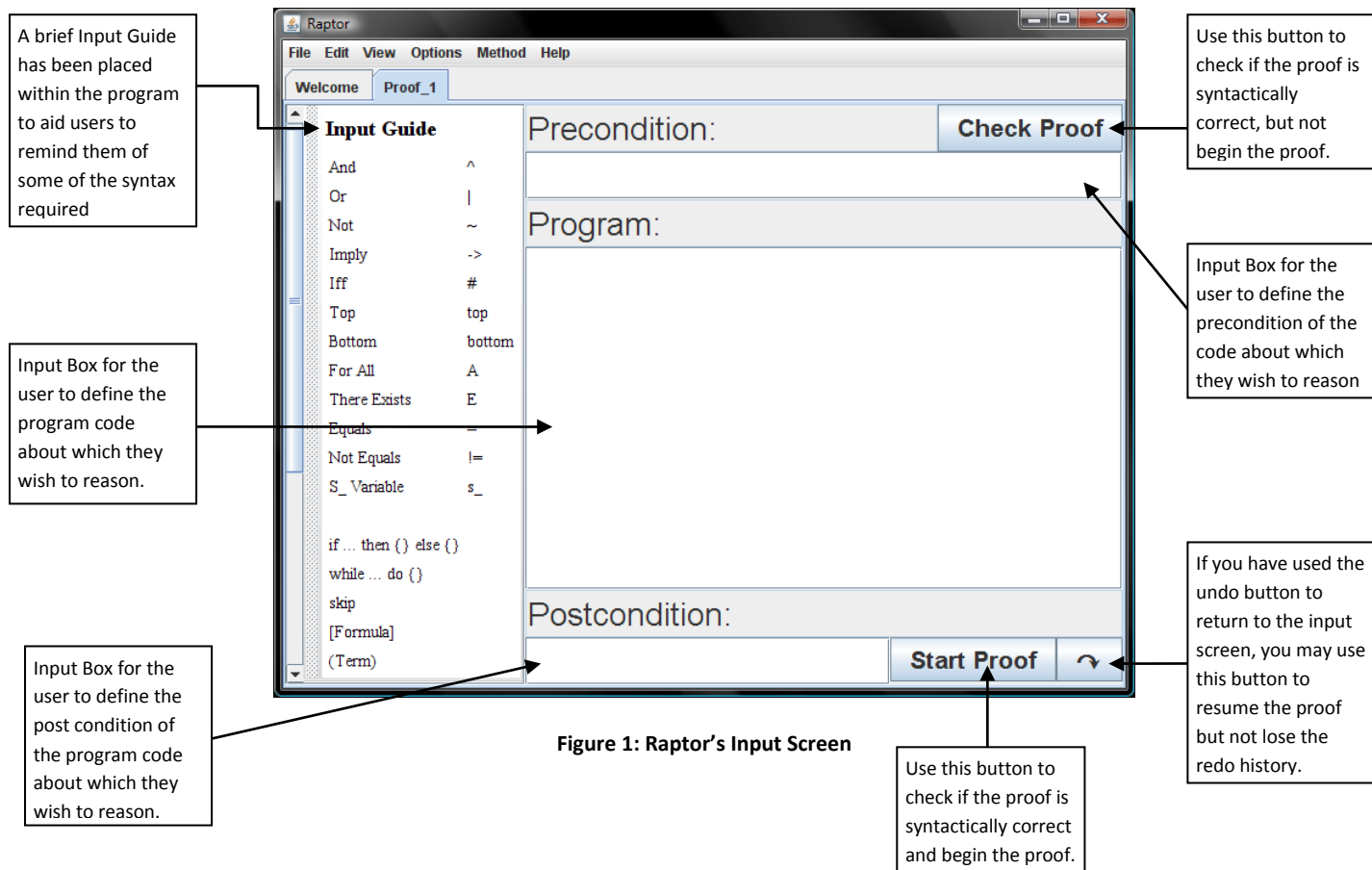
INPUT SCREEN

A brief Input Guide has been placed within the program to aid users to remind them of some of the syntax required

Use this button to check if the proof is syntactically correct, but not begin the proof.

Input Box for the user to define the precondition of the code about which they wish to reason

Input Box for the user to define the program code about which they wish to reason.

If you have used the undo button to return to the input screen, you may use this button to resume the proof but not lose the redo history.

Input Box for the user to define the post condition of the program code about which they wish to reason.

Figure 1: Raptor's Input Screen

Use this button to check if the proof is syntactically correct and begin the proof.

THE RULES

semi	assg
method	if
while	skip

∧I	∧E
∨I	∨E
→I	→E
¬I	¬E
⊥I	⊥E
¬¬	↔I
↔E	↔I2
↔E2	EM
PC	

∃I	∃E
∀I	∀E
Reflexivity	=Sub
∀→E	∀E√

√	Instantiate
TM√	TM
Cut	

Figure 2: Raptor's Proof Rule Pane

SEMI RULE

1. Select a body of more than one program line which involves a semi-colon and click semi.
2. The body of program lines is split at the last semi-colon and the two parts of the body are put into their own proof boxes and these boxes are added to the proof. An unknown is added at the start of the first box; representing the condition that holds before the code execution begins. Another unknown is added such that it is the goal of the first box and the assumption to the second box; representing a condition which holds between lines of code. Another unknown is added to the end of the second box; representing the condition which holds after the code has completed.

ASSIGNMENT RULE

1. Select a program line which represents an assignment and click assg.
2. For the goal formula below the assignment, which must not be unknown, every occurrence of the left hand side of the assignment replaced by its right hand side and added to the proof, above the assignment as the new goal.

METHOD RULE

1. Select the assignment statement which is an assignment involving a method call and click method.
2. The precondition and post condition of the method call is added to the proof; the goal below the method call remains a goal in the proof box, the post condition is added as an assumption and the precondition is added as a sub goal in the proof box.

IF RULE

1. Select an if statement and click if.
2. Two new proof boxes are added to the proof; the assumption to one box is the condition of the if statement and the assumption of the other is the negated version of the condition. Both boxes have the same goal which you must instantiate.   Similar to the semi rule, an unknown is added to the start of both boxes which represents the condition that holds before the if statement.

WHILE RULE

1. Select a while loop and click while.
2. A new proof box is added to the proof; two assumptions are added to this new box, the while loop condition and the loop invariant. You must instantiate an invariant appropriate to the while loop. The goal for this box is the invariant, as you must re-establish the invariant after the loop code.

SKIP RULE

1. Select the skip statement and click skip.
2. The proof line below the skip statement is added above the skip as the new goal.

∧I RULE

FORWARDS:

1. Select an empty line and click ∧I.
2. Select the two formulae for which you would like to introduce the And; the order you select them in is the order in which they will appear in the resulting formula.

BACKWARDS:

1. Select a goal line which is an And formula and click ∧I.
2. Two new proof boxes will appear, one with the left sub formula of the formula from step 1, as its goal and the other with the right sub formula as its goal.

∧E RULE

FORWARDS:

1. Select an empty line and click ∧E.

2. You will then be asked if you wish to derive the left sub formula or the right sub formula or both.

1. Select a goal formula, which can be any formula.
2. You will then be asked if the selected formula should be on the left or right side of the And symbol.
3. Type in the formula for the other side.

∨I RULE

1. Select an empty line and click ∨I.
2. Select the line containing the formula you wish to be used by this rule.
3. You will then be asked if the selected formula should be on the left or right side of the Or symbol.
4. Type in the formula for the other side.

1. Select the goal line which is an Or formula and click ∨I.
2. You will then be asked which side of the Or formula to derive as the new goal; the left side or the right.

∨E RULE

1. Select an empty line and click ∨E.
2. Select the Or formula you would like to use the ∨E rule with.
3. You will then be asked for the goal that you would like to derive from the Or Elimination. Two new proof boxes will be added to your proof with the left side of the Or as the assumption at the top of one of the boxes and the right as the assumption of the other box, and the goal for each box is the formula you were asked to enter to be derived.

1. Select a goal formula that you wish to derive and click ∨E.
2. Select the Or formula that you would like to derive the goal from.
3. Two new proof sub boxes will be added to your proof with the left side of the Or as the assumption at the top of one of the boxes and the right as the assumption of the other, and the goal being the goal for each box.

→I RULE

1. Select an empty line and click →I.

2. You will be asked to input the implication which you would like to derive.
3. A new proof box is added to the proof with the antecedent of the implication that you wish to prove at the top of the box as an assumption and the consequent as the goal for the box.

BACKWARDS:

1. Select a goal which is an implication formula and click →I.
2. A new proof box is added to the proof with the antecedent of the goal at the top of the box as an assumption and the consequent as the goal for the box.

→E RULE

FORWARDS:

1. Select an empty line and click →E.
2. Select the left sub formula (the antecedent) of the implication for which you would like to perform an →E.
3. Select the implication.
4. The consequent of the implication is added to the proof.

BACKWARDS:

1. Select the goal line which has the consequent of the implication for which you wish to perform the →E.
2. Select the implication.
3. The antecedent is added to your proof as the new goal.

⊥I RULE

FORWARDS:

1. Select an empty line and click ⊥I.
2. Select the two contradictory formulae.

BACKWARDS:

1. Select the goal which is a Bottom formula and click ⊥I.
2. Select the formula for which you would like to derive the contradiction.
3. The negated version of the selected formula is added as the new goal to the proof.

⊥E RULE

FORWARDS:

1. Select an empty line and click ⊥E.
2. Select the line containing the Bottom formula.
3. Enter the formula you would like to introduce.

BACKWARDS:

1. Select a goal formula and click ⊥E.
2. A Bottom formula is added to the proof as the new goal.

PC Rule

Forwards:

1. Select an empty line and click PC.
2. Enter the formula you would like to derive by contradiction.
3. A new proof box is added to your proof with the negated version of your entered formula as an assumption to the box and Bottom as its goal.

Backwards:

1. Select the goal formula you wish to derive by contradiction and click PC.
2. A new proof box is added to the proof with the negated version of the goal as its assumption and Bottom as its goal.

¬¬ Rule

Forwards:

1. Select an empty line and click ¬¬.
2. Select a Not-Not formula to eliminate the ¬¬ from.

Backwards:

1. Select a goal formula and click the ¬¬.
2. A new formula is added which is the selected formula with Not-Not on the front of it, as the new goal.

↔I Rule

Forwards:

1. Select an empty line and click ↔I.
2. You will be asked to input the If-And-Only-If formula you would like to derive.
3. Two new proof boxes are added to the proof for proving the left side of the If-And-Only-If implies the right side and the other to prove the right side implies the left side.

Backwards:

1. Select the If-And-Only-If formula you would like to derive and click ↔I.
2. Two new proof boxes are added to the proof for proving the left side of the If-And-Only-If implies the right side and the other to prove the right side implies the left side.

↔E Rule

Forwards:

1. Select an empty line and click ↔E.
2. Select a formula equivalent to either side of the If-And-Only-If formula for which you like to perform an ↔E.
3. Select the If-And-Only-If formula.
4. The sub formula from the other side of the If-And-Only-If is added to the proof.

1. Select a goal line which matches either side of the If-And-Only-If formula for which you would like to perform an ↔E.
2. Select the If-And-Only-If formula.
3. The sub formula from the other side of the If-And-Only-If is added to the proof.

CUT RULE

1. Select a goal line or an empty line and click Cut.
2. Type in the Lemma you wish to add to your proof. A Lemma is an intermediate formula that is inserted between the proof you have so far and the goal you are trying to prove, as a sub goal.

EM RULE

FORWARDS:

1. Select an empty line and click EM.
2. Type the formula that you would like to generate the Lemma for, e.g. if you type "a", "a∨¬a" is generated and added to the proof as a sub goal.

BACKWARDS:

1. Select the goal line of the form "a∨¬a" and click EM.
2. The proof step is shown to complete the box in which the line is contained, i.e. the empty line above the goal line is removed and the proof is complete.

∃I RULE

FORWARDS:

1. Select an empty line and click ∃I.
2. Select a formula that contains unbound variables.
3. You can now either type in the formula you wish to derive, which will be checked for correctness, or skip this and type the variable you now wish to bind and the bound variable to use.
4. The There-Exists formula from step 3 is added to the proof.

BACKWARDS:

1. Select the goal line which is a There-Exists formula and click ∃I.
2. You will be asked which term you would like to replace the bound variable with.

3. This There-Exists formula with the bound variable substituted will be added to the proof as the new goal.

∃E Rule

Forwards:

1. Select an empty line and click ∃E.
2. Select a There-Exists formula for which you would like to perform the elimination.
3. Type the formula you would like to derive.
4. A new proof box is added to the proof which has as its first line a declaration for a new, unused constant (or a skolem term), an assumption of the There-Exists formula with the skolem term substituted into it and the goal being the formula you had typed in.

Backwards:

1. Select a goal line and click ∃E.
2. Select a There-Exists formula for which you would like to perform the elimination.
3. A new proof box is added to the proof which has as its first line a declaration for a new, unused constant (or a skolem term), an assumption of the There-Exists formula with the skolem term substituted into it and the goal being the formula you had selected in step 1.

∀I Rule

Forwards:

1. Select an empty line and click ∀I.
2. Type in the Forall formula you would like to derive.
3. A new proof box is added to the proof which has as its first line a declaration for a new, unused constant (or a skolem constant) and the goal is the Forall formula of the Forall typed in step 2, with the skolem term substituted into it.

Backwards:

1. Select a goal line which is a Forall formula and click ∀I.
2. A new proof box is added to the proof which has as its first line a declaration for a new, unused constant (or a skolem constant) and the goal is the Forall formula of the Forall selected in step 1, with the skolem term substituted into it.

∀E Rule

Forwards:

1. Select an empty line and click ∀E.
2. Select the Forall formula to which you would like to apply the elimination rule.
3. You will be asked which term you would like to replace the bound variable with.
4. The formula of the Forall with the variable substituted by the term typed in step 3 is added to the proof.

1. Select the goal which you would like to derive from a Forall elimination and click ∀E.
2. You may either specify the Forall formula, will be checked for correctness, or skip this and type the variable you now wish to bind and type the bound variable for the Forall formula.
3. The Forall formula is added to the proof as the new goal.

REFLEXIVITY RULE

FORWARDS:

1. Select an empty line and click Reflexivity.
2. Type the term to apply the reflexivity rule to.
3. The formula of the form "a=a" is added to the proof.

BACKWARDS:

1. Select the formula of the form "a=a" and click Reflexivity.
2. The proof step is shown to complete the box in which the line is contained, i.e. the empty line above the goal line is removed and the proof is complete.

=SUB RULE

FORWARDS:

1. Select an empty line and click =Sub.
2. Select, in any order, the formula into which you would like to substitute and the equality that you would like to substitute into the formula.
3. If there are more than one occurrences of the term to be substituted you will be given a prompt to type in the formula you would like to be the result, i.e. choosing which occurrences to replace, if you wish to replace all occurrences, click OK. If there is only one occurrence, you will be notified and you must click OK to proceed with the substitution.
4. The resulting formula, with the substitutions made, is added to the proof.

BACKWARDS:

1. Select the goal into which you would like to carry out a substitution and click =Sub.
2. Select the equality that you would like to substitute into the formula selected in step 1.
3. If there are more than one occurrences of the term to be substituted you will be given a prompt to type in the formula you would like to be the result, i.e. choosing which occurrences to replace, if you wish to replace all occurrences, click OK. If there is only one occurrence, you will be notified and you must click OK to proceed with the substitution.
4. The resulting formula, with the substitutions made, is added to the proof as the new goal.

∀→E RULE

FORWARDS:

1. Select an empty line and click ∀→E.

2. Select, in any order, the Forall formula, which has as its sub formula an Implication, to apply this rule to and the formula which represents the antecedent of the implication, which has the variable substituted by a term.
3. The consequent of the implication is added to the proof.

BACKWARDS:

1. Select the consequent of the Implication formula which is the sub formula of a Forall and click ∀→E.
2. Select the Forall formula to which you want to apply this rule.
3. If it is not possible to automatically deduce the term which has been substituted for the variable of the Forall, you will be prompted for it, else it will be done automatically.
4. The antecedent is added to the proof as the new goal.

TICK RULE

FORWARDS:

1. Select an empty line and click √ (Tick).
2. Select a formula above the empty to be copied.
3. The selected line is inserted into the proof where the empty was, shifting the empty down one line.

BACKWARDS:

1. Select goal line and click √ (Tick).
2. Select the line that matches the goal exactly, the proof step is complete, i.e. the empty line is removed.

RAPTOR:

1. Select goal line which is an unknown formula and click √ (Tick).
2. Select the line that you wish to unify this unknown with, i.e. the formula you want to instantiate this unknown with.

INSTANTIATE RULE

1. Select a goal line which is an unknown formula and click Instantiate.
2. Enter the formula that you wish to instantiate the unknown with.

TM-TICK RULE

FORWARDS:

TM-Tick cannot be applied forwards.

BACKWARDS:

1. Select a goal line and click TM√.

2. You may now select the lines of the proof that you have used to justify or deduce that the line selected in step 1 follows on from the last proof line above it.
3. The proof step is completed, i.e. the empty line is removed.

TM RULE

FORWARDS:

1. Select an empty line and click TM.
2. You may now select the lines that you have used to justify or deduce the formula you will be asked type in the next step.
3. Type the formula you would like to add to the proof.

BACKWARDS:

1. Select a goal line and click TM.
2. You may now select the lines that you have used to justify or deduce the formula you will be asked type in the next step.
3. Type the formula you would like to add to the proof as the new goal.