Coqatoo

Generating Natural Language Versions of Coq Proofs

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Motivation

- Proofs can sometimes be hard to understand, particularly for less-experienced users
- CtCoq and its successor Pcoq are no longer available

Example

Input

```
Lemma conj_imp_equiv : forall P Q R:Prop,
    (P /\ Q -> R) <-> (P -> Q -> R).
Proof.
    intros. split. intros H HP HQ. apply H. apply conj.
assumption. assumption. intros H HPQ. inversion HPQ.
apply H. assumption. assumption.
Qed.
```

Coqatoos rewriting algorithm can be decomposed in three steps:

1. Information extraction
2. Proof tree construction
3. Tactic-based rewriting

Step 1: Information extraction

Coqatoo captures the intermediary proof states

```
1 subgoal

================================
forall P Q R : Prop, (P /\ Q -> R) <-> (P -> Q -> R)
```

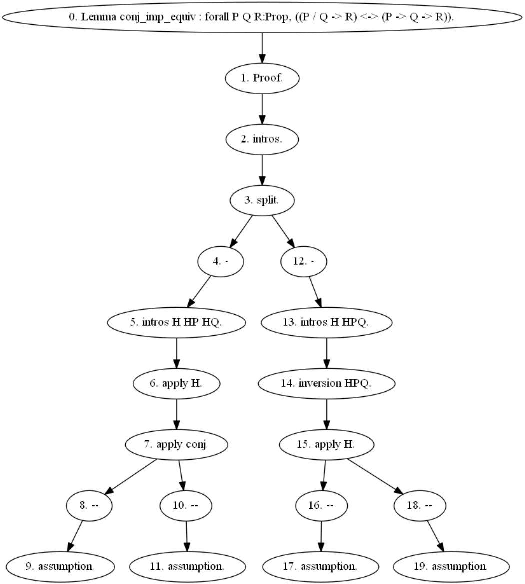
Listing 1: State before executing the first intros tactic

```
1 subgoal

P, Q, R : Prop
================================
(P /\ Q -> R) <-> (P -> Q -> R)
```

Listing 2: State after executing the first intros tactic

Step 2: Proof tree construction



Step 3: Tactic-based rewriting

Example

Output

```
Lemma conj_imp_equiv : forall P Q R:Prop, ((P /\ Q -> R) <-> (P -> Q -> R)).
Proof.
  (* Assume that P, Q and R are arbitrary objects of type Prop. Let us show that
      (P /\ Q -> R) <-> (P -> Q -> R) is true. *) intros.
  split.
  - (* Case (P /\ Q -> R) -> P -> Q -> R: *)
    (* Suppose that P, Q and P /\ Q -> R are true. Let us show that R is true.
     *) intros H HP HQ.
    (* By our hypothesis P /\ Q -> R, we know that R is true if P /\ Q  is true.
       *) apply H.
    apply conj.
    -- (* Case P: *)
       (* True, because it is one of our assumptions. *) assumption.
    -- (* Case Q: *)
       (* True, because it is one of our assumptions. *) assumption.
  - (* Case (P -> Q -> R) -> P /\ Q -> R: *)
    (* Suppose that P /\ Q and P -> Q -> R are true. Let us show that R is true.
       *) intros H HPQ.
    (* By inversion on P /\ Q, we know that P, Q are also true. *) inversion HPQ
     .
    (* By our hypothesis P -> Q -> R, we know that R is true if P and Q are true
     . *) apply H.
    -- (* Case P: *)
       (* True, because it is one of our assumptions. *) assumption.
    -- (* Case Q: *)
       (* True, because it is one of our assumptions. *) assumption.
Qed.
```

Listing 3: Output in annotation mode

Demonstration

Comparison

Disadvantages

- It only works on proofs whose tactics are supported, while the approach of Coscoy et al. worked on any proof.
- It may require additional verifications to ensure that unecessary information (e.g., an assertion which isn't used) is not included in the generated proof.

- It enables us to more easily control the size and verbosity of the generated proof (one or two sentences per tactic by default).
- It maintains the order and structure of the user's original proof script; this is not necessarily the case in Coscoy et al.

Future work

- Increase the number of supported tactics
  - Goal: Software Foundations
- Add partial support for automation
- Integration with existing development environments
- Add a LaTeX output mode