Reactive Synthesis - Hands-on Exercise

Lectures: Moshe Vardi
Hands-on exercise: Rüdiger Ehlers

13th June 2013
Overview

1. Available Tools for LTL Synthesis
2. An overview of \textbf{Acacia+}
3. Traffic Light Example
4. Rotation Sorter Exercise
### Full LTL
- **Lily** (Jobstmann and Bloem, 2006)
- **Unbeast** (Ehlers, 2011)
- **Acacia+** (Bohy et al., 2012)

### Subset of LTL
- **Marduk/Ratsy** (Bloem et al., 2010)
- **JTLV synthesizer** (Pnueli et al., 2010)
- **Bassist** (Ehlers, 2012)

More tools: [http://tinyurl.com/ilikesynthesis](http://tinyurl.com/ilikesynthesis)
Acacia+ (Bohy et al., 2012)

Features

- Support for full LTL
- Optimized algorithms for specifications of the form $\phi_1 \land \phi_2 \land \ldots \phi_n$
- Can also optimize the solution towards mean-payoff objectives

Techniques

- Is based on bounded synthesis (Schewe and Finkbeiner, 2007; Filio et al., 2009), which in turn builds on Safraless synthesis (Kupferman and Vardi, 2005)
- Written in Python and C
- Interfaces with external LTL-to-automata translators
Example

An intersection

Interface
- $AP_I = \{t_n, t_e, t_w, t_s\}$
- $AP_O = \{g_n, g_e, g_w, g_s\}$

Specification
- $G(g_s \rightarrow (\neg g_e \land \neg g_w))$
- $G(t_s \rightarrow F g_s)$
- ...
Improving the quality of service

Idea: green light may only be given if car is detected. New conjuncts:

\[ G(g_n \rightarrow t_n) \land G(g_s \rightarrow t_s) \land G(g_e \rightarrow t_e) \land G(g_w \rightarrow t_w) \]
Extending the Example

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The setting is unrealizable now!

Reason: Trigger signal might be released before green light is given. So we cannot avoid a conflict of:

- \[ G(t_s \rightarrow F g_s) \land G(t_w \rightarrow F g_w) \]
- \[ G(g_s \rightarrow (\neg g_w \land \neg g_e)) \land G(g_w \rightarrow (\neg g_n \land \neg g_s)) \]
- \[ G(g_s \rightarrow t_s) \land G(g_w \rightarrow t_w) \]
Extending the Example

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- \[ G(g_s \rightarrow t_s) \land G(g_w \rightarrow t_w) \]

Fixing unrealizability: adding assumptions

\[ (G((t_s \land \neg g_s) \rightarrow Xt_s) \land \ldots \land G((t_w \land \neg g_w) \rightarrow Xt_w)) \rightarrow \psi \]
**Rotation Sorter**

**Input/Output per direction**
- Inputs $x$ and $y$ encode packet destinations
- Output $p$ pushes packets off the rotating table
- Output $b$ triggers the in-belt
Timing

### Example (transport packet by 240°)

<table>
<thead>
<tr>
<th></th>
<th>$x_0$</th>
<th>1</th>
<th>1</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_0$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$p_0$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$p_1$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$p_2$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>$b_0$</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Semantics

<table>
<thead>
<tr>
<th>Meaning</th>
<th>$x$</th>
<th>$y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No packet</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Transport by 120°</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Transport by 240°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Transport by 360°</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(Almost) a possible part of the specification

$$(x_0 \land y_0) \rightarrow (b_0 \land X\neg p_1 \land XX\neg p_2 \land XXX p_0)$$

Exercise: Rüdiger Ehlers (UCB/Cornell) Reactive Synthesis Berkeley, 13th June 2013 8/10
Your turn!

http://lit2.ulb.ac.be/acaciaplus/onlinetest/
More on the practical side of synthesis

Suggestion
Try out a synthesizer for generalized reactivity specifications, such as, e.g., Marduk/Ratsy\textsuperscript{a}, Gr1c\textsuperscript{b}, or Slugs\textsuperscript{c}.

\begin{itemize}
\item \textsuperscript{a}http://rat.fbk.eu/ratsy/
\item \textsuperscript{b}https://github.com/slivingston/gr1c
\item \textsuperscript{c}https://github.com/LTLMoP/slugs
\end{itemize}

Some light reading material


References II


