Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutior

Restriction

Total Wid Theory Resolution

Narrow Theory Resolutio

Applicatio

Examples of Theory Resolution Empirical Results

Summary and Critique

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

with figures from:

 Jörg Siekmann and Graham Wrightson, An Open Research Problem: Strong Completeness of R. Kowalski's Connection Graph Proof Procedure, Computational Logic: Logic Programming and Beyond 2002: 231-252

April 6, 2006

The Idea

(reserver) Idea Example (Ordinary Resolution) Resolution Resolution Resolution Narrow Resolution Theory Resolution Theory Resolution Theory Resolution Examples of Theory Resolution Examples Theory C Theory Resolution Theory Resolution Theory Resolution Theory Resolution Theory Resolution Examples Theory C Theory Resolution Resolution Theory Resolution Theory Resolution Theory Resolution Resolution Theory Resolution Theory Resolution Resolution

Summary and Critique

by Theory

Mark Stickel (author) Christian

The Idea

(presenter) Example (Ordinary Resolution) Resolve: $a \lor b \lor c$ $\neg a \lor d$ to $b \lor c \lor d$ Idea Resolve not just over inverse literals but over sets of inconsistent clauses.

by Theory

Mark Stickel (author) Christian

The Idea

Mark Stickel (author) Christian (presenter)

by Theory

Example (Theory Resolution, here: theory of partial ordering (ORD)) With theory $(\neg (x < x), (x < y) \land (y < z) \supset (x > z))$, resolve $(a < b) \lor P$ $(b < c) \lor Q$ $(c < d) \lor R$ $\neg (a < d) \lor S$ $P \lor Q \lor R \lor S$

Idea

to

Resolve not just over inverse literals but over sets of inconsistent clauses.

T-satisfiability

Idea

Theory Resolution

by Theory

Mark Stickel (author) Christian Fritz (presenter)

Restriction

Total Wide Theory Resolution

Narrow Theory Resolution Theory

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Definition (*T*-interpretation)

A <u>*T*-interpretation</u> is an interpretation that satisfies the theory T.

Definition (*T*-unsatisfiable)

A set of clauses S is <u>T-unsatisfiable</u> if no <u>T-interpretation</u> satisfies S. S is minimally <u>T-unsatisfiable</u> if S is <u>T-unsatisfiable</u> but no proper subset of S is.

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Definition (Theory Resolution)

liven:	C_1, C_2	,,	C_m, I	$m \ge$	1
	-1, -2	,,	,		

decompose to:

 $K_1 \vee L_1, \ldots, K_m \vee L_m, m \ge 1, K_i$ non-empty clauses

 $R_1, \ldots, R_n, n \ge 0$, unit clauses

suppose: $K_1, \ldots, K_m, R_1, \ldots, R_n$ are *T*-unsatisfiable

then: $L_1 \vee \cdots \vee L_m \vee \neg R_1 \vee \cdots \vee \neg R_n$ is a *T*-resolvent

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior

Matings

Application

examples of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Example (Theory Resolution)

Given:	C_1 ,	$C_2,\ldots,$	C_m, r	$n \ge 1$

decompose to:

 $K_1 \vee L_1, \ldots, K_m \vee L_m, m \ge 1, K_i$ non-empty clauses

 $R_1,\ldots,R_n,n\geq 0, {\rm unit\ clauses}$

suppose: $K_1, \ldots, K_m, R_1, \ldots, R_n$ are *T*-unsatisfiable

then: $L_1 \vee \cdots \vee L_m \vee \neg R_1 \vee \cdots \vee \neg R_n$ is a *T*-resolvent

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior

Matings

Application

of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Example (Theory Resolution)

Given: decompose to:	$C_1, C_2, \dots, C_m, m \ge 1$ (a < b) $\lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$ $K_1 \lor L_1, \dots, K_m \lor L_m, m \ge 1, K_i \text{ non-empty clauses}$
	$R_1,\ldots,R_n,n\geq 0, ext{unit clauses}$
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
then:	$L_1 \vee \cdots \vee L_m \vee \neg R_1 \vee \cdots \vee \neg R_n$ is a <i>T</i> -resolvent

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutior

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution

Matings

Application

examples of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Example (Theory Resolution)

Given:	$C_1, C_2, \ldots, C_m, m \ge 1$ $(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
decompose to:	$K_1 \lor L_1, \ldots, K_m \lor L_m, m \ge 1, K_i$ non-empty clauses $(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$ $R_1, \ldots, R_n, n \ge 0$, unit clauses
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
then:	$L_1 \lor \cdots \lor L_m \lor \neg R_1 \lor \cdots \lor \neg R_n$ is a <i>T</i> -resolvent

▲□▶ ▲@▶ ▲글▶ ▲글▶ 글 - 이익은

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Example (Theory Resolution)

Given:	$C_1, C_2, \ldots, C_m, m \geq 1$
	$(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
decompose to:	$K_1 \vee L_1, \ldots, K_m \vee L_m, m \ge 1, K_i$ non-empty clauses
	$(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
	$R_1,\ldots,R_n,n\geq 0, ext{unit clauses}$
	{}
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
then:	$L_1 \vee \cdots \vee L_m \vee \neg R_1 \vee \cdots \vee \neg R_n$ is a <i>T</i> -resolvent

<ロ>

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

de

Narrow Theory Resolutior

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Example (Theory Resolution)

Given:	$C_1, C_2, \ldots, C_m, m \geq 1$
	$(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
ecompose to:	$K_1 \vee L_1, \ldots, K_m \vee L_m, m \geq 1, K_i$ non-empty clauses
	$(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
	$R_1,\ldots,R_n,n\geq 0, ext{unit clauses}$
	{}
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
	$(a < b), (b < c), (c < d), \neg(a < d)$ are T -unsatisfiable
then:	$L_1 \vee \cdots \vee L_m \vee \neg R_1 \vee \cdots \vee \neg R_n$ is a <i>T</i> -resolvent

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

C

Narrow Theory Resolutior

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theory Resolution: Definition & Example

Example (Theory Resolution)

Given:	$C_1, C_2, \ldots, C_m, m \geq 1$
	$(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
lecompose to:	$K_1 \vee L_1, \ldots, K_m \vee L_m, m \ge 1, K_i$ non-empty clauses
	$(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg (a < d) \lor S$
	$R_1, \ldots, R_n, n \geq 0$, unit clauses
	8
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
	$(a < b), (b < c), (c < d), \neg(a < d)$ are <i>T</i> -unsatisfiable
then:	$L_1 \vee \cdots \vee L_m \vee \neg R_1 \vee \cdots \vee \neg R_n$ is a <i>T</i> -resolvent
	$P \lor Q \lor R \lor S$ is a <i>T</i> -resolvent

Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theorem (Soundness)

Let T be a theory, S a set of clauses, and C a T-resolvent of S. Then every T-interpretation that satisfies S also satisfies C.

Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wide Theory Resolution

Narrow Theory Resolutior

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theorem (Soundness)

Let T be a theory, S a set of clauses, and C a T-resolvent of S. Then every T-interpretation that satisfies S also satisfies C.

Nice, but is it useful?

Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wide Theory Resolution

Narrow Theory Resolution

Theory Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theorem (Soundness)

Let T be a theory, S a set of clauses, and C a T-resolvent of S. Then every T-interpretation that satisfies S also satisfies C.

Nice, but is it useful? No!

Problem

Generating all possible resolvents is impractical.

Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wide Theory Resolution

Narrow Theory Resolution

Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Theorem (Soundness)

Let T be a theory, S a set of clauses, and C a T-resolvent of S. Then every T-interpretation that satisfies S also satisfies C.

Nice, but is it useful? No!

Problem

Generating all possible resolvents is impractical.

Solution

Restrict the types of resolution steps allowed but maintain completeness!

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wid Theory Resolution

Theory Resolutio

Matings

Applicatio

of Theory Resolution Empirical Results

Summary and Critique

Types of Resolvents

Definition (Theory Resolution; Types of Resolvents)

Given: decompose to:

 \mathbf{S}

 $C_1, C_2, \dots, C_m, m \ge 1$ $K_1 \lor L_1, \dots, K_m \lor L_m, m \ge 1, K_i$ non-empty clauses

 $R_1, \ldots, R_n, n \ge 0$, unit clauses

uppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
then:	$L_1, \ldots, L_m, \neg R_1, \ldots, \neg R_n$ is a <i>T</i> -resolvent

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wid Theory Resolution

Narrow Theory Resolutio

Matings

Application

of Theory Resolution Empirical Results

Summary and Critique

Types of Resolvents

Definition (Theory Resolution; Types of Resolvents)

Given: decompose to:

$$\begin{split} & C_1, C_2, \ldots, C_m, m \geq 1 \\ & K_1 \vee L_1, \ldots, K_m \vee L_m, m \geq 1, K_i \text{ non-empty clauses} \end{split}$$

suppose:

then:

 $\begin{aligned} & R_1, \dots, R_n, n \geq 0, \text{ unit clauses} \\ & (total) \\ & K_1, \dots, K_m, R_1, \dots, R_n \text{ are } T \text{-unsatisfiable} \\ & L_1, \dots, L_m, \neg R_1, \dots, \neg R_n \text{ is a } T \text{-resolvent} \end{aligned}$

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution decom

 \mathbf{S}

Restriction

Total Wid Theory Resolution

Narrow Theory Resolution

Examples of Theory Resolution Empirical Results

Summary and Critique

Types of Resolvents

Definition (Theory Resolution; Types of Resolvents)

Given:	$C_1, C_2, \ldots, C_m, m \geq 1$
pose to:	$K_1 \vee L_1, \ldots, K_m \vee L_m, m \ge 1, K_i \text{ non-empty clauses}$
	unit <i>(narrow)</i>
	$R_1, \ldots, R_n, n \geq 0$, unit clauses
	(total)
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
then:	$L_1, \ldots, L_m, \neg R_1, \ldots, \neg R_n$ is a <i>T</i> -resolvent

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutior

Restriction

Total Wid Theory Resolution

Narrow Theory Resolutio

A 11

Examples of Theory Resolution Empirical Results

Summary and Critique

Types of Resolvents

Definition (Theory Resolution; Types of Resolvents)

Given:	$C_1, C_2, \ldots, C_m, m \geq 1$
decompose to:	$K_1 \vee L_1, \ldots, K_m \vee L_m, m \geq 1, K_i \text{ non-empty clauses}$
	m = 1 (unary), $m = 2$ (binary) unit (narrow)
	$R_1,\ldots,R_n,n\geq 0, \text{ unit clauses}$
	(total)
suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
then:	$L_1, \ldots, L_m, \neg R_1, \ldots, \neg R_n$ is a <i>T</i> -resolvent

Types of Resolvents

Definition (Theory Resolution; Types of Resolvents)

I	Given:	$C_1, C_2, \ldots, C_m, m \geq 1$
	decompose to:	$K_1 \vee L_1, \ldots, K_m \vee L_m, m \geq 1, K_i \text{ non-empty clauses}$
		m = 1 (unary), $m = 2$ (binary) unit (narrow)
		$R_1,\ldots,R_n,n\geq 0, \text{ unit clauses}$
		(total)
	suppose:	$K_1, \ldots, K_m, R_1, \ldots, R_n$ are <i>T</i> -unsatisfiable
	then:	$L_1, \ldots, L_m, \neg R_1, \ldots, \neg R_n$ is a <i>T</i> -resolvent

- ordinary resolution is total, narrow, and binary
- *P* is a unary total narrow ORD-resolvent of $(a < a) \lor P$
- $P \lor Q \lor R \lor S$ is a 4-ary total narrow ORD-resolvent of $(a < b) \lor P, (b < c) \lor Q, (c < d) \lor R, \neg(a < d) \lor S$
- $(a < c) \lor P \lor Q$ is a partial narrow ORD-resolvent of $(a < b) \lor P$ and $(b < c) \lor Q$ with condition $R_1 = \neg(a < c)$

Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Theory Resolution Theory

Matings

Examples of Theory Resolution Empirical Results

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wide Theory Resolution

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution Empirical Results



Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior Theory Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Total Wide Theory Resolution

total: unconditioned, i.e. no R's needed to resolve wide: keys can be non-unit

Theorem

Total wide theory resolution is complete.

Intuition

- given a procedure to find all minimally *T*-unsatisfiable subsets of a set of clauses only containing predicates in *T*,
- split the set S of clauses to refute into $S_P \cup S_{\bar{P}}$, P the predicates in T,
- first resolve away all predicates P using T-resolution,
- then, resolve the rest using ordinary resolution which is a special case of total wide resolution.

Narrow Theory Resolution

narrow: keys are unit, resolve over sets of literals - no disjunctions anymore!

Total

- like ordinary resolution but resolving over more than just two literals
- demanding on the decision procedure of the theory

Partial

- less demanding: just name a condition for T-unsatisfiability of literals
 - key selection and corresponding condition matter
 - may resolve upon unrelated clauses
 - introduced conditions may not be refutable

bxample__

- we could resolve (a < b) ∨ P and (c < d) ∨ R with condition (b < c) ∧ (d < a) but that's unless
- keys should be suitably related
- * size and amount of introduced residues should be minimized

Tuea

I heory Resolution

by Theory

Mark

Stickel (author) Christian

Fritz (presenter)

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution Theory

Matings

Application

Examples of Theory Resolution Empirical Results

Narrow Theory Resolution

narrow: keys are unit, resolve over sets of literals - no disjunctions anymore!

Total

- like ordinary resolution but resolving over more than just two literals
- · demanding on the decision procedure of the theory

Partial

- less demanding: just name a condition for *T*-unsatisfiability of literals
- key selection and corresponding condition matter
- may resolve upon unrelated clauses
- introduced conditions may not be refutable

Example

- we could resolve $(a < b) \lor P$ and $(c < d) \lor R$ with condition $(b < c) \land (d < a)$ but that's useless
- keys should be suitably related
- size and amount of introduced residues should be minimized

Theor

Restrictions

Mark Stickel (author) Christian

Fritz (presenter)

Total Wide Theory Resolution

Narrow Theory Resolution

Mating

Application

Examples of Theory Resolution Empirical Results

Narrow Theory Resolution

narrow: keys are unit, resolve over sets of literals - no disjunctions anymore!

Total

- like ordinary resolution but resolving over more than just two literals
- · demanding on the decision procedure of the theory

Partial

- less demanding: just name a condition for *T*-unsatisfiability of literals
- key selection and corresponding condition matter
- may resolve upon unrelated clauses
- introduced conditions may not be refutable

Example

- we could resolve (a < b) ∨ P and (c < d) ∨ R with condition (b < c) ∧ (d < a) but that's useless
- keys should be suitably related
- · size and amount of introduced residues should be minimized

Idea

I heory Resolution

Mark

Stickel (author) Christian

Fritz (presenter)

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution

Mating

Application

Examples of Theory Resolution Empirical Results

narrow (vs wide): Keys are unit

Key Selection

Incremental Approach (Partial Narrow Theory Resolution)

consider:

```
L_{11} \lor L_{12} \cdots \lor L_{1m}
L_{21} \lor L_{22} \cdots \lor L_{2m}
\vdots
L_{n1} \lor L_{n2} \cdots \lor L_{nm}
```

- Naively: consider all combinations $S = \{L_{1i_1}, L_{2i_2}, \ldots, L_{ni_n}\}$
- Instead can work incrementally upon keys $K \subseteq S$ if:
 - there is a set of literals $R = \{R_1, \ldots, R_k\}$ (a condition) such that $K \cup \{\neg R_1, \ldots, \neg R_k\}$ is minimally *T*-unsatisfiable, and
 - $(S K) \cup \{R_1 \lor \cdots \lor R_k\}$ is minimally *T*-unsatisfiable
- called key selection criterion
- preserves completeness

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution Theory

Matings

Examples of Theory Resolution Empirical Results

narrow (vs wide): Keys are unit

Theory Matings

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutio

Theory Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Definition (Path)

A <u>path</u> through clauses C_1, \ldots, C_m is a set of literals $K_i \in C_i$.

Theorem (Mating)

A set of clauses is unsatisfiable iff every path though it contains a complementary pair of literals.

Example

```
L_{11} \lor L_{12} \cdots \lor L_{1m}
L_{21} \lor L_{22} \cdots \lor L_{2m}
\vdots
L_{n1} \lor L_{n2} \cdots \lor L_{nm}
```

narrow (vs wide): Keys are unit

Theory Matings

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutio

Theory Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Definition (Path)

A path through clauses C_1, \ldots, C_m is a set of literals $K_i \in C_i$.

Theorem (Theory Mating)

A set of clauses is **T-unsatisfiable** iff every path though it contains a **T-unsatisfiable set** of literals.

Example

```
L_{11} \lor L_{12} \cdots \lor L_{1m}
L_{21} \lor L_{22} \cdots \lor L_{2m}
\vdots
L_{n1} \lor L_{n2} \cdots \lor L_{nm}
```

narrow (vs wide): Keys are unit

Theory Matings

Automate Deduction by Theory Resolution Mark

Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutio

Theory Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

Definition (Path)

A path through clauses C_1, \ldots, C_m is a set of literals $K_i \in C_i$.

Theorem (Theory Mating)

A set of clauses is **T-unsatisfiable** iff every path though it contains a **T-unsatisfiable set** of literals.

Example

```
L_{11} \lor L_{12} \cdots \lor L_{1m}
L_{21} \lor L_{22} \cdots \lor L_{2m}
\vdots
L_{n1} \lor L_{n2} \cdots \lor L_{nm}
```

cf. total narrow theory resolution

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restriction

Total Wid Theory Resolutior

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Examples of Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Hyperresolution

- From the *electron clauses* $K_i \lor L_i$ with K_i a literal and L_i a clause, and the *nucleus clause* $\neg K_1 \lor \cdots \lor \neg K_m \lor R$ derive $L_1 \lor \cdots \lor L_m \lor R$.
- corresponds to:
 - partial, narrow theory resolution, where
 - $\neg K_1 \lor \cdots \lor \neg K_m \lor R$ is a consequence of the theory

Procedural Attachment

- Expressions can be "evaluated" to produce new ones, e.g. $2 < 3 \rightarrow true$
- corresponds to:
 - unary theory resolution,
 - can be extended to attach procedures to sets of literals
 e.g. a < b, b < c → a < c

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Hyperresolution

- From the *electron clauses* $K_i \lor L_i$ with K_i a literal and L_i a clause, and the *nucleus clause* $\neg K_1 \lor \cdots \lor \neg K_m \lor R$ derive $L_1 \lor \cdots \lor L_m \lor R$.
- corresponds to:
 - partial, narrow theory resolution, where
 - $\neg K_1 \lor \cdots \lor \neg K_m \lor R$ is a consequence of the theory

Procedural Attachment

- Expressions can be "evaluated" to produce new ones, e.g. $2 < 3 \rightarrow true$
- corresponds to:
 - unary theory resolution,
 - can be extended to attach procedures to sets of literals
 e.g. a < b, b < c → a < c

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Paramodulation/Equality/Unification

- P(b) is a *paramodulant* of P(a) and a = b
- the empty clause is a *E-resolvent* of $P(a), \neg P(b)$, and a = b
- $a \neq b$ is a *RUE-resolvent* of P(a) and $\neg P(b)$

• corresponds to:

• some form of binary-partial/total theory resolution, with equality theory

Resolution for Modal Logic of Belief

• recognize unsatisfiability of- and resolve over modal belief literals, e.g.

 $\Box p \lor A, \Box (p \supset q) \lor B, \neg \Box q \lor C \quad \rightarrow \quad A \lor B \lor C$

• corresponds to:

• wide total theory resolution with theory of modal belief

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Paramodulation/Equality/Unification

- P(b) is a *paramodulant* of P(a) and a = b
- the empty clause is a *E-resolvent* of $P(a), \neg P(b)$, and a = b
- $a \neq b$ is a *RUE-resolvent* of P(a) and $\neg P(b)$
- corresponds to:
 - some form of binary-partial/total theory resolution, with equality theory

Resolution for Modal Logic of Belief

• recognize unsatisfiability of- and resolve over modal belief literals, e.g.

$$\Box p \lor A, \Box (p \supset q) \lor B, \neg \Box q \lor C \quad \rightarrow \quad A \lor B \lor C$$

• corresponds to:

· wide total theory resolution with theory of modal belief

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restrictions

Total Wid Theory Resolution

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Taxonomic Reasoning in KRYPTON

	1.	$Boy(x) \supset Person(x)$
	2.	$[Boy(x) \land Sex(x, y)] \supset Male(y)$
	3.	$Girl(x) \supset Person(x)$
	4.	$[Girl(x) \land Sex(x, y)] \supset Female(y)$
	5.	$[NoSon(x) \land Child(x, y)] \supset Girl(y)$
	6.	$[NoDaughter(x) \land Child(x, y)] \supset Boy(y)$
	7.	$Person(x) \supset Sex(x, sk1(x))$
	8.	$Male(x) \equiv \neg Female(x)$
hypothesis	9.	NoSon(Chris)
hypothesis	10.	NoDaughter(Chris)
negated conclusion	11.	Child(Chris, sk2)
resolve 11 and 5, simplify by 9	12.	Girl(sk2)
resolve 12 and 3	13.	Person(sk2)
resolve 7 and 13	14.	Sex(sk2, sk1(sk2))
resolve 11 and 6, simplify by 10	15.	Boy(sk2)
resolve 15 and 2	17.	$Sex(sk2, x) \supset Male(x)$
resolve 14 and 17	18.	Male(sk1(sk2))
resolve 8 and 18	19.	$\neg Female(sk1(sk2))$
resolve 12 and 4	20.	$Sex(sk2, x) \supset Female(x)$
resolve 14 and 20, simplify by 19 $$	21.	

Figure 1: Resolution Proof for Childless Problem

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutior Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Taxonomic Reasoning in KRYPTON

 $Boy(x) \supset Person(x)$

	2.	$[Boy(x) \land Sex(x, y)] \supset Male(y)$
	3.	$Girl(x) \supset Person(x)$
	4.	$[Girl(x) \land Sex(x, y)] \supset Female(y)$
	5.	$[NoSon(x) \land Child(x, y)] \supset Girl(y)$
	6.	$[NoDaughter(x) \land Child(x, y)] \supset Boy(y)$
	7.	$Person(x) \supset Sex(x, sk1(x))$
	8.	$Male(x) \equiv \neg Female(x)$
hypothesis	9.	NoSon(Chris)
hypothesis	10.	NoDaughter(Chris)
negated conclusion	11.	Child(Chris, sk2)
resolve 11 and 5, simplify by 9	12.	Girl(sk2)
resolve 12 and 3	13.	Person(sk2)
resolve 7 and 13	14.	Sex(sk2, sk1(sk2))
resolve 11 and 6, simplify by 10	15.	Boy(sk2)
resolve 15 and 2	17.	$Sex(sk2, x) \supset Male(x)$
resolve 14 and 17	18.	Male(sk1(sk2))
resolve 8 and 18	19.	$\neg Female(sk1(sk2))$
resolve 12 and 4	20.	$Sex(sk2, x) \supset Female(x)$
resolve 14 and 20, simplify by 19	21.	

1.

Figure 1: Resolution Proof for Childless Problem

hypothesis	9.	NoSon(Chris)
hypothesis	10.	NoDaughter(Chris)
negated conclusion	11.	Child(Chris, sk2)
resolve 11 and 9	12.	Girl(sk2)
resolve 11 and 10, simplify by 12	13.	

Figure 2: KRYPTON Proof for Childless Problem

Deduction by Theory

Mark (author) Christian (presenter)

Examples of Theory Resolution

Taxonomic Reasoning in KRYPTON

	1. 2. 3.	[Boy Girl	$ \begin{aligned} (x) \supset Person(x) \\ (x) \wedge Sex(x,y) \\ (x) \supset Person(x) \end{aligned} $	$\supset Male(y)$		
	4. 5.		$l(x) \wedge Sex(x,y)$			
	5. 6.		$Son(x) \wedge Child($ $Daughter(x) \wedge C$			
	0. 7.		$son(x) \supset Sex(x)$		(Boy(y))	
	8.		$e(x) \equiv \neg Female$			
hypothesis	9.		on(Chris)	$\mathcal{L}(x)$		
hypothesis	10.		aughter(Chris)		
negated conclusion	11.		d(Chris, sk2)	,		
resolve 11 and 5, simplify	by 9 12.		(sk2)			
resolve 12 and 3	13.	Pers	on(sk2)			
resolve 7 and 13	14.	Sex(sk2, sk1(sk2))			
resolve 11 and 6, simplify	by 10 15.	Boy	(sk2)			
resolve 15 and 2	17.	Sex	$sk2, x) \supset Male$	(x)		
resolve 14 and 17	18.	Mal	e(sk1(sk2))			
resolve 8 and 18		$\neg Female(sk1(sk2))$				
resolve 12 and 4		$Sex(sk2, x) \supset Female(x)$				
resolve 14 and 20, simplify	by 19 21.					
	1: Resolution		f for Childless I			
hypothesis		9.	NoSon(Chris)			
hypothesis		10. NoDaughter(Chris)				
negated conclusion		11.	Child(Chris, s	sk2)		
resolve 11 and 9		12.	Girl(sk2)			
resolve 11 and 10, sin	nplify by 12	13.				
F	igure 2: Kry	PTON	Proof for Child	lless Problem		
Built In Inputted Der	ived Reta	ined	Successful	Time	Proof	
Axioms Formulas Form	nulas Form	ulas	Unifications	(seconds)	Length	
none 11 1	.0 20	0	37	1.1	9	
1-8 3	2	5	4	0.4	2	

narrow (vs wide): Keys are unit

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restrictions

Total Wid Theory Resolution

Narrow Theory Resolution Theory Matings

Application

Examples of Theory Resolution

Empirical Results

Summary and Critique

Empirical Results

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restriction

Total Wie Theory Resolutio Narrow Theory Resolutio

Mating

Application

Examples of Theory Resolution

Empirical Results

and Critiqu

Schubert's Steamroller Problem: Axioms

	1. $Wolf(x) \supset Animal(x)$						
	2. $Fox(x) \supset Animal(x)$						
	3. $Bird(x) \supset Animal(x)$	Wolves, foxes, birds,					
	4. $Caterpillar(x) \supset Animal(x)$						
	5. $Snail(x) \supset Animal(x)$	imals, and there are					
	6. $Grain(x) \supset Plant(x)$	there are some grains					
	7. $[Snail(x) \land Bird(y)] \supset Much-smaller(x, y)$	0					
	8. $[Caterpillar(x) \land Bird(y)] \supset Much-smaller$	(x,y) ery animal either likes					
	9. $[Bird(x) \land Fox(y)] \supset Much-smaller(x, y)$	much smaller than itse					
	10. $[Fox(x) \land Wolf(y)] \supset Much-smaller(x, y)$						
	11. $[Wolf(x) \land Fox(y)] \supset \neg Likes-to-eat(x, y)$	Caterpillars and snails					
	12. $[Wolf(x) \land Grain(y)] \supset \neg Likes-to-eat(x, y)$	which are much smal					
	13. $[Bird(x) \land Snail(y)] \supset \neg Likes-to-eat(x, y)$						
	14. $[Bird(x) \wedge Caterpillar(y)] \supset Likes-to-eat(x, x)$	y) are much smaller that					
	15. $Caterpillar(x) \supset Plant(h(x))$	to eat foxes or grains					
	16. $Caterpillar(x) \supset Likes-to-eat(h(x))$	U					
	17. $Snail(x) \supset Plant(i(x))$	pillars but not snails.					
	18. $Snail(x) \supset Likes-to-eat(i(x))$						
	 Wolf(a-wolf) 	eat some plants.					
	20. Fox(a-fox)						
	 Bird(a-bird) Caterpillar(a-caterpillar) 	Therefore, there is a					
	23. Snail(a-snail)	grain-eating animal.					
	24. Grain(a-grain)						
2	25. $Animal(x) \supset [[Plant(y) \supset Likes-to-eat(x, y)]$						
	$[Animal(z) \land Much-smaller(z, x) \land Plant)$	$(w) \land Likes-to-eat(z, w)] \supset Likes-to-eat(x, z)]]$					
	Negated conclusion for Proof (a):	Tiles to set (a s) M. Tiles to set (a s)					
2	26. $\neg Animal(x) \lor \neg Animal(y) \lor \neg Grain(z) \lor \neg$	$Likes-to-eat(y,z) \lor \neg Likes-to-eat(x,y)$					
	Negated conclusion for Proof (b):						
	$[Animal(x) \land Animal(y)] \supset Grain(j(x, y))$						
2							
2	$\neg Animal(x) \lor \neg Animal(y) \lor \neg Likes-to-eat(y, j(x, y)) \lor \neg Likes-to-eat(x, y)$						

Wolves, foxes, birds, caterpillars, and snails are animals, and there are some of each of them. Also, there are some grains, and grains are plants. Every animal either likes to eat all plants or all animals much smaller than itself that like to eat some plants. Caterpillars and snails are much smaller than birds, which are much smaller than foxes, which in turn are much smaller than wolves. Wolves do not like to eat foxes or grains, while birds like to eat caterpillars but not snails. Caterpillars and snails like to eat some plants.

Therefore, there is an animal that likes to eat a grain-eating animal.

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restriction

Total Wide Theory Resolution

Theory Resoluti Theory

Mating

Applicatio

Examples of Theory Resolution

Empirical Results

Summary and Critiqu

Schubert's Steamroller Problem: Axioms

- 1. $Wolf(x) \supset Animal(x)$
- 2. $Fox(x) \supset Animal(x)$
- 3. $Bird(x) \supset Animal(x)$
- 4. $Caterpillar(x) \supset Animal(x)$
- 5. $Snail(x) \supset Animal(x)$
- 6. $Grain(x) \supset Plant(x)$
- 7. $[Snail(x) \land Bird(y)] \supset Much-smaller(x, y)$
- 8. $[Caterpillar(x) \land Bird(y)] \supset Much-smaller(x, y)$
- 9. $[Bird(x) \wedge Fox(y)] \supset Much-smaller(x, y)$
- 10. $[Fox(x) \land Wolf(y)] \supset Much-smaller(x, y)$
- 11. $[Wolf(x) \land Fox(y)] \supset \neg Likes-to-eat(x, y)$
- 12. $[Wolf(x) \land Grain(y)] \supset \neg Likes-to-eat(x, y)$
- 13. $[Bird(x) \land Snail(y)] \supset \neg Likes-to-eat(x, y)$
- 14. $[Bird(x) \land Caterpillar(y)] \supset Likes-to-eat(x, y)$
- 15. $Caterpillar(x) \supset Plant(h(x))$
- 16. $Caterpillar(x) \supset Likes-to-eat(h(x))$
- 17. $Snail(x) \supset Plant(i(x))$
- 18. $Snail(x) \supset Likes-to-eat(i(x))$
- 19. Wolf(a-wolf)
- 20. Fox(a-fox)
- 21. Bird(a-bird)
- 22. Caterpillar(a-caterpillar)
- 23. Snail(a-snail)
- 24. Grain(a-grain)
 - 5. $Animal(x) \supset [[Plant(y) \supset Likes-to-eat(x, y)] \lor [[Animal(z) \land Much-smaller(z, x) \land Plant(w) \land Likes-to-eat(z, w)] \supset Likes-to-eat(x, z)]]$

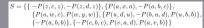
Negated conclusion for Proof (a):

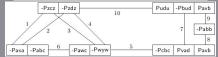
 $26. \quad \neg Animal(x) \lor \neg Animal(y) \lor \neg Grain(z) \lor \neg Likes-to-eat(y,z) \lor \neg Likes-to-eat(x,y)$

Negated conclusion for Proof (b):

- 27. $[Animal(x) \land Animal(y)] \supset Grain(j(x, y))$
- 28. $\neg Animal(x) \lor \neg Animal(y) \lor \neg Likes-to-eat(y, j(x, y)) \lor \neg Likes-to-eat(x, y)$

Connection-Graph Resolution





Heuristic to decide among resolutionsTheory resolution here: add more links

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restriction

Total Wide Theory Resolution

Narrow Theory Resoluti Theory

Mating

Applicatio

Examples of Theory Resolution

Empirical Results

Summary and Critiqu

Schubert's Steamroller Problem: Axioms

- 1. $Wolf(x) \supset Animal(x)$
- 2. $Fox(x) \supset Animal(x)$
- 3. $Bird(x) \supset Animal(x)$
- 4. $Caterpillar(x) \supset Animal(x)$
- 5. $Snail(x) \supset Animal(x)$
- 6. $Grain(x) \supset Plant(x)$
- 7. $[Snail(x) \land Bird(y)] \supset Much-smaller(x, y)$
- 8. $[Caterpillar(x) \land Bird(y)] \supset Much-smaller(x, y)$
- 9. $[Bird(x) \wedge Fox(y)] \supset Much-smaller(x, y)$
- 10. $[Fox(x) \land Wolf(y)] \supset Much-smaller(x, y)$
- 11. $[Wolf(x) \land Fox(y)] \supset \neg Likes-to-eat(x, y)$
- 12. $[Wolf(x) \land Grain(y)] \supset \neg Likes-to-eat(x, y)$
- 13. $[Bird(x) \land Snail(y)] \supset \neg Likes-to-eat(x, y)$
- 14. $[Bird(x) \land Caterpillar(y)] \supset Likes-to-eat(x, y)$
- 15. $Caterpillar(x) \supset Plant(h(x))$
- 16. $Caterpillar(x) \supset Likes-to-eat(h(x))$
- 17. $Snail(x) \supset Plant(i(x))$
- 18. $Snail(x) \supset Likes-to-eat(i(x))$
- 19. Wolf(a-wolf)
- 20. Fox(a-fox)
- 21. Bird(a-bird)
- 22. Caterpillar(a-caterpillar)
- 23. Snail(a-snail)
- 24. Grain(a-grain)
 - 5. $Animal(x) \supset [[Plant(y) \supset Likes-to-eat(x, y)] \lor [[Animal(z) \land Much-smaller(z, x) \land Plant(w) \land Likes-to-eat(z, w)] \supset Likes-to-eat(x, z)]]$

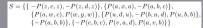
Negated conclusion for Proof (a):

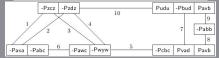
 $26. \quad \neg Animal(x) \lor \neg Animal(y) \lor \neg Grain(z) \lor \neg Likes-to-eat(y,z) \lor \neg Likes-to-eat(x,y)$

Negated conclusion for Proof (b):

- 27. $[Animal(x) \land Animal(y)] \supset Grain(j(x, y))$
- 28. $\neg Animal(x) \lor \neg Animal(y) \lor \neg Likes-to-eat(y, j(x, y)) \lor \neg Likes-to-eat(x, y)$

Connection-Graph Resolution





- Heuristic to decide among resolutions
- Theory resolution here: add more links

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolutio

Restriction

Total Wide Theory Resolution

Narrow Theory Resoluti Theory

Mating

Applicatio

Examples of Theory Resolution

Empirical Results

Summary and Critiqu

Schubert's Steamroller Problem: Axioms

- 1. $Wolf(x) \supset Animal(x)$
- 2. $Fox(x) \supset Animal(x)$
- 3. $Bird(x) \supset Animal(x)$
- 4. $Caterpillar(x) \supset Animal(x)$
- 5. $Snail(x) \supset Animal(x)$
- 6. $Grain(x) \supset Plant(x)$
- 7. $[Snail(x) \land Bird(y)] \supset Much-smaller(x, y)$
- 8. $[Caterpillar(x) \land Bird(y)] \supset Much-smaller(x, y)$
- 9. $[Bird(x) \wedge Fox(y)] \supset Much-smaller(x, y)$
- 10. $[Fox(x) \land Wolf(y)] \supset Much-smaller(x, y)$
- 11. $[Wolf(x) \land Fox(y)] \supset \neg Likes-to-eat(x, y)$
- 12. $[Wolf(x) \land Grain(y)] \supset \neg Likes-to-eat(x, y)$
- 13. $[Bird(x) \land Snail(y)] \supset \neg Likes-to-eat(x, y)$
- 14. $[Bird(x) \land Caterpillar(y)] \supset Likes-to-eat(x, y)$
- 15. $Caterpillar(x) \supset Plant(h(x))$
- 16. $Caterpillar(x) \supset Likes-to-eat(h(x))$
- 17. $Snail(x) \supset Plant(i(x))$
- 18. $Snail(x) \supset Likes-to-eat(i(x))$
- 19. Wolf(a-wolf)
- 20. Fox(a-fox)
- 21. Bird(a-bird)
- 22. Caterpillar(a-caterpillar)
- 23. Snail(a-snail)
- 24. Grain(a-grain)
 - 25. $Animal(x) \supset [[Plant(y) \supset Likes-to-eat(x, y)] \lor [[Animal(x) \land Much-smaller(x, x) \land Plant(w) \land Likes-to-eat(x, w)] \supset Likes-to-eat(x, z)]]$

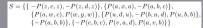
Negated conclusion for Proof (a):

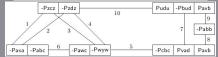
 $26. \neg Animal(x) \lor \neg Animal(y) \lor \neg Grain(z) \lor \neg Likes-to-eat(y,z) \lor \neg Likes-to-eat(x,y)$

Negated conclusion for Proof (b):

- 27. $[Animal(x) \land Animal(y)] \supset Grain(j(x, y))$
- 28. $\neg Animal(x) \lor \neg Animal(y) \lor \neg Likes-to-eat(y, j(x, y)) \lor \neg Likes-to-eat(x, y)$

Connection-Graph Resolution





- Heuristic to decide among resolutions
- Theory resolution here: add more links!

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wide Theory Resolution

Narrow Theory Resolutio Theory Matings

Applicatio

Examples of Theory Resolution Empirical Results

Summary and Critique

Built In	Inputted	Derived	Retained	Successful	Time	Proof
Axioms	Formulas	Formulas	Formulas	Unifications	(seconds)	Length
none	26	4,518	72	$245,\!820$	$5,\!694$	61
1 - 6	20	2,751	119	$57,\!100$	1,261	27
1 - 10	16	257	23	$3,\!602$	88	32
1 - 13	13	215	37	3,353	73	32
1 - 14	12	115	23	$2,\!494$	54	32
1 - 18	8	310	20	$11,\!130$	224	17
none	27	?	?	?	?	?
1 - 6	21	7,037	30	$172,\!338$	11,027	34
1 - 10	17	243	23	5,793	140	21
1 - 13	14	216	20	$5,\!836$	143	21
1 - 14	13	151	19	$5,\!840$	124	21
1 - 18	9	155	29	5,822	138	17

Empirical Results

narrow (vs wide): Keys are unit

Empirical Results

Automated Deduction by Theory Resolution

Mark Stickel (author) Christian Fritz (presenter)

Idea

Theory Resolution

Restriction

Total Wide Theory Resolution

Theory Resolutio Theory Matings

Applicatio

Examples of Theory Resolution Empirical Results

Summary and Critique

Built In	Inputted	Derived	Retained	Successful	Time	Proof
Axioms	Formulas	Formulas	Formulas	Unifications	(seconds)	Length
none	26	4,518	72	$245,\!820$	$5,\!694$	61
1 - 6	20	2,751	119	$57,\!100$	1,261	27
1 - 10	16	257	23	$3,\!602$	88	32
1 - 13	13	215	37	3,353	73	32
1 - 14	12	115	23	$2,\!494$	54	32
1 - 18	8	310	20	$11,\!130$	224	17
none	27	?	?	?	?	?
1-6	21	7,037	30	$172,\!338$	11,027	34
1 - 10	17	243	23	5,793	140	21
1 - 13	14	216	20	$5,\!836$	143	21
1–14	13	151	19	$5,\!840$	124	21
1 - 18	9	155	29	5,822	138	17

• no statements about preprocessing time (to build in the axioms)

Summary

Mark Stickel (author) Christian Fritz (presenter)

Deduction by Theory

- Idea
- Theory Resolution
- Restrictions
- Total Wide Theory Resolution
- Narrow Theory Resolution Theory Matings
- Application

Examples of Theory Resolution Empirical Results

Summary and Critique

- Total theory resolution is possible if there exists a decision procedure for deciding *T*-unsatisfiability of arbitrary sets of clauses over predicates in the theory.
- Partial narrow theory resolution is possible if there exists a decision procedure for deciding *T*-unsatisfiability of sets of literals under some condition.

Summary

Mark Stickel (author) Christian Fritz (presenter)

Deduction by Theory

- Idea
- Theory Resolution
- Restrictions
- Total Wide Theory Resolution
- Narrow Theory Resolution Theory Matings
- Application
- Examples of Theory Resolution Empirical Results
- Summary and Critique

- Total theory resolution is possible if there exists a decision procedure for deciding *T*-unsatisfiability of arbitrary sets of clauses over predicates in the theory.
- Partial narrow theory resolution is possible if there exists a decision procedure for deciding *T*-unsatisfiability of sets of literals under some condition.

Theory Resolution is ..

- .. a nice generalization of many existing approaches,
- .. formalizes a way for integrating domain knowledge into resolution
- .. can reduce proof lengths and time

narrow (vs wide): Keys are unit

Critique

Mark Stickel (author) Christian Fritz (presenter)

Deduction by Theory

Idea

Theory Resolution

Restrictions

Total Wide Theory Resolution

Narrow Theory Resolutio Theory Matings

Application

Examples of Theory Resolution Empirical Results

Summary and Critique

- key selection criterion for partial narrow TR seems very strong
- no results for restrictions, "which should I use?"
- no empirical results on satisfiable cases
- moves part of problem into decision procedure of theory or in the presented empirical problem into the preprocessing
- hard to gage the practical impact