Interactive Configuration and Constraints

Knowledge, Filtering algorithms and Extensions

Élise Vareilles
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Mines Albi
24th of November 2015
Interactive Configuration and Constraints

Knowledge, Filtering algorithms and Extensions

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Mines Albi
24th of November 2015
Definition: Interactive Configuration

\{Components\} + Dialogue with the user ↦ solution(s) [Mittal et
Frayman1989], [Tiihonen1996], [Sabin1998], [Veron2001]
Definition : Interactive Configuration

\{\text{Components}\} + \text{Dialogue with the user} \mapsto \text{solution(s)} \quad \text{[Mittal et Frayman1989], [Tiihonen1996], [Sabin1998], [Veron2001]}

Products
Definition: Interactive Configuration

\{\text{Components}\} + \text{Dialogue with the user} \rightsquigarrow \text{solution(s)} \ [\text{Mittal et al.}]

Frayman1989, [Tiihonen1996], [Sabin1998], [Veron2001]
Definition: Interactive Configuration

\{\text{Components}\} \, + \, \text{Dialogue with the user} \implies \text{solution(s)} [\text{Mittal et Frayman1989}, [\text{Tiihonen1996}], [\text{Sabin1998}], [\text{Veron2001}]]

Combinatorial Problem\(^1\)

17 pieces $\Rightarrow$ 6000 combinations
Conception and Configuration


Needs

⇒ Creative
Conception and Configuration

Extreme case of the routine design.... [Brown1989], [Sabin1998], [Stumptner1997]

Needs
⇒ Creative
⇒ Innovative
Context

Conception and Configuration

Extreme case of the routine design.... [Brown1989], [Sabin1998], [Stumptner1997]

Needs
⇒ Creative
⇒ Innovative
⇒ Routine
Context

Conception and Configuration

Extreme case of the routine design.... [Brown1989], [Sabin1998], [Stumptner1997]

- Needs ⇒ Creative
- Field + Innovative
- Process ⇒ Routine
- Exhaustiveness ⇒ Configuration
My Research Works

3 Theses soutenues
3 Theses en cours
4 Projets de Recherche
10 articles WoS

Configurateur
CoFiADe
C.S.P.
C.B.R.
Ontologie
Base de connaissances

Utilisateur
Problème

Configuration
Pasons
Processus
Évaluation
Optimisation

C.B.R.  C.S.P.  Ontologie

Validation
Extraction
Formalisation

Expert
Connaissances

Conception Avion
Rénovation Bâtiment
Produit Système
Service
Maintenance Hélicoptère

Appel d’offres
Cablage Grue

3 Thèses soutenues
3 Thèses en cours
4 Projets de Recherche
10 articles WoS
Topics and Agenda

1. Configurateur
2. CoFiADe
3. C.S.P.
4. C.B.R.
5. Ontology
6. Knowledge Base
7. Needs
8. Bill of Material
9. Evaluation
10. Optimization
11. Process
12. Configuration

[T/one.pnum] : Knowledge Formalization and Constraints
[T/two.pnum] : Knowledge Exploitation and Filtering
[T/three.pnum] : Extensions of configuration

6/32 24th of November 2015  É. Vareilles (Mines Albi)  HDR Presentation
Topics and Agenda

[T1]: Knowledge Formalization and Constraints

C.B.R.  C.S.P.  Ontology

Knowledge Base
Topics and Agenda

[T1]: Knowledge Formalization and Constraints

[T2]: Knowledge Exploitation and Filtering

- Configurateur
- CoFiADe
- C.B.R.
- C.S.P.
- Ontology
- Knowledge Base

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[T1] – Knowledge and Constraints

Configuration

Needs

Bill of Material

Process

Evaluation

Optimization

Configurateur
CoFiADe

[T1]: Knowledge Formalization and Constraints

C.B.R.  C.S.P.  Ontology

Knowledge Base
[T1] – Knowledge and Constraints

Configuration and Generic Model

Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]
Configuration and Generic Model

Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]
Configuration and Generic Model

Capitalized Knowledge... [Sabin1996], [Sabin1998], [Felfernig2015]
Capitalized Knowledge...
[Sabin1996], [Sabin1998], [Felfernig2015]
Configuration and Generic Model

Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]
Configuration and Generic Model

Capitalized Knowledge... [Sabin1996], [Sabin1998], [Felfernig2015]
Configuration and Generic Model

Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]

Expert

Knowledge

Components

Compatibility

Mathematical Formulae

Academic/General KN

Empiric/Contextual KN

...
Configuration and Generic Model

Capitalized Knowledge... [Sabin1996], [Sabin1998], [Felfernig2015]

- C.B.R. (CBR Engine)
- C.S.P. (Case-Based Reasoning)
- Ontology
- Knowledge Base

- Components
- Compatibility
- Mathematical Formulae
- Academic/General KN
- Empiric/Contextual KN
- ...
Definition: Constraint Satisfaction Problem

Triplet \((V, D, C)\) [Montanari1974]

Solution

\[ \forall k \sum_{i=1}^{k} v_i \in V, |D_{v_i}| = 1 \land \exists m \sum_{j=1}^{m} c_j \in C, c_j = \bot \]
Configuration and Constraints

Association of several types of CSP

C.S.P.
Knowledge Base
Configuration and Constraints

Association of several types of CSP

- CSP Discrete
- CSP Numerical
- CSP Mixed
- CSP Temporal
- CSP Conditional

Knowledge Base
Configuration and Constraints

Association of several types of CSP

- CSP Discrete
- CSP Numerical
- CSP Mixed
- CSP Temporal
- CSP Conditional

Knowledge Base

V.H.T.
Th. Vareilles
Th. Djefel
IJPR 2013
Collaboration Pays Bas

A.T.L.A.S.
Th. Codet
C.R.I.B.A.
2Π-MCO

Hélimaintenance
Conception Avion
Maintenance Hélicoptère
Rénovation Bâtiment
Appel d’offres Cablage Grue

Collaboration Danemark
Constraints and Empirical Knowledge

Abacus Formalization

C.S.P.
Knowledge Base
Constraints and Empirical Knowledge

Abacus Formalization

C.S.P.
Knowledge Base

Continuous Cooling Flow Diagram
[T1] – Knowledge and Constraints

Constraints and Empirical Knowledge

Abacus Formalization

C.S.P.
Knowledge Base

Continuous Cooling Flow Diagram

V.H.T.
Traitement Thermique

Th. Vareilles
JIM 2008, EAAI 2009
Constraintes and Ontology

Knowledge Structure

C.S.P.  Ontology
Knowledge Base
[T1] – Knowledge and Constraints

Contraintes and Ontology

Knowledge Structure

C.S.P. Ontology

Knowledge Base

Base de connaissances
Ontologie et CSP

Domaine

Système

Tâche

Longeron

Avion

Cockpit

Longeron U

Longeron I

Exigences

Développement

Alternatives

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Contraintes and Ontology

Knowledge Structure

C.S.P. Ontology

Knowledge Base

A.T.L.A.S.

Conception Avion

Th. Abeille

AIEDAM 2014
Constraints and Contextual Knowledge

Use of relevant knowledge in a specific and changing context.

C.B.R.  C.S.P.
Knowledge Base
Constraints and Contextual Knowledge

Use of relevant knowledge in a specific and changing context.

C.B.R.  C.S.P.
Knowledge Base

\[ cc(LV_R, \text{sim}^{cc}_g, ms, LV_C, LV_P, FP) \]
Constraints and Contextual Knowledge

Use of relevant knowledge in a specific and changing context.

C.B.R.  C.S.P.
Knowledge Base

cc\( (LV_R, \text{sim}_g^{CC}, ms, LV_C, LV_p, FP) \)

Hélimaintenance

Maintenance Hélicoptère

Th. Codet

EAAI 2012
[T1] – Knowledge and Constraints: Synthesis

Configuration

Needs

Bill of Material

Process

Evaluation

Optimization

Configurateur

CoFiADe

⊗ CSP

Empirical KN

Contextual KN

Ontology

C.B.R.

C.S.P.

Ontology

Knowledge Base

HDR Presentation
[T2] – Exploitation and Filtering

Configuration

- Needs
- Bill of Material
- Process
- Evaluation
- Optimization

[T2] : Exploitation of Knowledge and Filtering

C.B.R.  C.S.P.  Ontology
Knowledge Base
Design and Development of Filtering Algorithms

Interactions and Users’ Needs
[T2] – Exploitation and Filtering

Design and Development of Filtering Algorithms
Interactions and Users’ Needs

- Knowledge Base
- C.S.P.
- C.B.R.
- Ontology

User

Visualization of Solutions

C.B.R.  C.S.P.  Ontology
Knowledge Base
[T2] – Exploitation and Filtering

Design and Development of Filtering Algorithms

Interactions and Users’ Needs

User

Visualization of Solutions
Expression of Preferences

Configurateur

C.B.R.  C.S.P.  Ontology
Knowledge Base
[T2] – Exploitation and Filtering

Design and Development of Filtering Algorithms

Interactions and Users’ Needs

User

Visualization of Solutions
Expression of Preferences
Recommendations

Configurateur

C.B.R.  C.S.P.  Ontology

Knowledge Base
[T2] – Exploitation and Filtering

Design and Development of Filtering Algorithms
Interactions and Users’ Needs

User

Needs

Visualization of Solutions
Expression of Preferences
Recommendations
Evaluation of Solutions
Limitation of Evaluation

Evaluation

Configurateur

C.B.R.  C.S.P.  Ontology
Knowledge Base

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HDR Presentation
Design and Development of Filtering Algorithms

Interactions and Users’ Needs

User

Needs

Visualization of Solutions
Expression of Preferences
Recommendations
Evaluation of Solutions
Limitation of Evaluation
Optimization of Solutions

Configurateur

C.B.R.  C.S.P.  Ontology
Knowledge Base

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HDR Presentation
[T2] – Exploitation and Filtering

Filtering Methods
- Prune research space
  - Convergence
- Arc consistency for discrete or mixed CSP
- Box-consistency or Box-consistency for continuous or temporal Caps

Solving Methods
- Find one or more solutions.
- Exhaustive Exploration: Generate & test, Backtrack...
- Partial Exploration: Look ahead, Forward checking...

Compilation Maps
- Compilation of CSP into Knowledge Compilation Maps.
Filtering Methods

Prune research space $\rightarrow$ convergence

- Arc consistency for discrete or mixed CSP
- 2B-consistency or Box-consistency for continuous or temporal Caps
Filtering Methods

Prune research space $\leadsto$ convergence
- Arc consistency for discrete or mixed CSP
- 2B-consistency or Box-consistency for continuous or temporal Caps

Solving Methods

Find one or more solutions.
- Exhaustive Exploration: Generate & test, Backtrack …
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[T2] – Exploitation and Filtering

Filtering Methods

Prune research space $\leadsto$ convergence
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Solving Methods

Find one or more solutions.
- Exhaustive Exploration: Generate & test, Backtrack …
- Partial Exploration: Look ahead, Forward checking …

Compilation Maps

Compilation of CSP into Knowledge Compilation Maps.
Large diversity of Knowledge to use
Association of \(\otimes\) filtering methods
Large diversity of Knowledge to use

Association of \( \otimes \) filtering methods

Arc Consistency
2B Consistency
Quad Tree
Large diversity of Knowledge to use

Association of filtering methods

- Multi-intervals
- Piecewise Constraints
- Constraints Activation

- Arc Consistency
- 2B Consistency
- Quad Tree
Large diversity of Knowledge to use

Association of \( \otimes \) filtering methods

- Multi-intervals
- Piecewise Constraints
- Constraints Activation
- Arc Consistency
- 2B Consistency
- Quad Tree

Th. Vareilles
Th. Djefel
Th. Codet
Th. Barco
Filtering and Piecewise Constraints

Extension of Quad Trees [Haroud1996]
[T2] – Exploitation and Filtering

Filtering and Piecewise Constraints

Extension of Quad Trees [Haroud1996]
Filtering and Piecewise Constraints

Extension of Quad Trees [Haroud1996]

Inconsistent
Uninformed
Ignorant
Border
Multiple Border
Consistent

V.H.T.
Traitement Thermique

Th. Vareilles

JIM 2008, EAAI 2009
Filtering and Contextual Constraints
Similarity, occurrence frequency and filtering
Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering
Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering
Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering
Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering

Contexte triangle orange
Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering
Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering

Contexte triangle orange
[T2] – Exploitation and Filtering

Filtering and Contextual Constraints
Similarity, occurrence frequency and filtering

Contexte triangle **orange**
Filtering and Optimization
Evolutionary Algorithm and CSP

SPEA2
[T2] – Exploitation and Filtering

Filtering and Optimization
Evolutionary Algorithm and CSP

SPEA2

CSP
Filtering and Optimization

Evolutionary Algorithm and CSP

SPEA2

Generation

Crossing
[T2] – Exploitation and Filtering

Filtering and Optimization
Evolutionary Algorithm and CSP

SPEA2

- Generation
- Mutation
- Crossing
Filtering and Optimization

Evolutionary Algorithm and CSP

SPEA2

A.T.L.A.S.
Conception
Avion
Th. Djefel
IJPR 2013, CII 2014
[T2] – Exploitation and Filtering: Synthesis

Configuration

Needs

Bill of Material

Process

Evaluation

Optimization

- ⊗ methods
- Quad-Tree++
- Contextual C.
- Optimization

C.B.R.  C.S.P.  Ontology
Knowledge Base

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HDR Presentation
T[3] – Configuration and Extensions

T[3] : Configuration Extensions

Configuration

Needs

Bill of Material

Process

Evaluation

Optimization

Configurateur CoFiADe

C.B.R. C.S.P. Ontology Knowledge Base
Solutions Evaluation

From selling Price to others criteria:

- Response Time\[^{\text{Nikolaidou2002}}\],
- Thermal Performance,
- Carbon Footprint, …
Solutions Evaluation

From selling Price to others criteria:

- Response Time[^Nikolaidou2002],
- Thermal Performance,
- Carbon Footprint, …

From Products Configuration to...

- Processes Configuration (concurrent) [^Zhang2012], [^Campagna2013]
- documentation[^Rabiser2014],
- Engineering to Order (ETO).
Evaluation mono $\mapsto$ Multi-criteria

Several evaluations criteria.

Configuration

Evaluation
Evaluation mono ↔ Multi-criteria
Several evaluations criteria.

Configuration

Evaluation

V.H.T. + Traitement Thermique
Thermal Def.
Th. Vareilles
IJCIM 2007

A.T.L.A.S. + Conception Avion
Cost/Time
Th. Djefel
IJPR 2013

Hélimaintenance + Maintenance Hélicoptère
Time
Th. Codet
EAAI 2012

C.R.I.B.A. + Rénovation Bâtiment
Cost/Ener. Perf.
Th. Barco
CP 2015
From Products to Processes

Upstream: Bidding & Downstream: Assembly process, Development Projects

Configuration

Bill of Material

Process
From Products to Processes

Upstream: Bidding & Downstream: Assembly process, Development Projects

Configuration

Bill of Material

Process

2Π-MCO
Appel d'offres
Cablage Grue

A.T.L.A.S.
Conception
Avion

Th. Abeille
BOM
ETO

C.R.I.B.A.
Rénovation
Bâtiment

Th. Barco
BOM
Assembly

BOM
Doc. Bidding

HDR Presentation
From Configuration To ETO

Synchronization of processes
From Configuration To ETO

Synchronization of processes
Configuration and Extensions: Synthesis

- Multi-criteria Evaluation
- Processes
- Synchronization

Configuration

Needs

Bill of Material

Process

Evaluation

Optimization

Configurateur CoFiADe

C.B.R.  C.S.P.  Ontology

Knowledge Base

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HDR Presentation
Conclusion and Perspectives

Configuration

Needs
- Bill of Material
- Process
- Evaluation
  - Optimization

Knowledge Base
- C.B.R.
- C.S.P.
- Ontology

Extensions of configuration

Knowledge Formalization and Constraints

[T1]: Knowledge Formalization and Constraints

[T2]: Exploitation of Knowledge and Filtering

[T3]: Extensions of configuration

É. Vareilles (Mines Albi)
Conclusion and Perspectives

4 projects (subv. 660KE), 3 PhD Students (110%) + 3 in progress (120%), 10 WoS, 3 software mock-ups
Conclusion and Perspectives

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4 projects (subv. 660KE), 3 PhD Students (110%) + 3 in progress (120%), 10 WoS, 3 software mock-ups
Conclusion and Perspectives
Conclusion and Perspectives
Optimization & Configuration

- Validation our approach SPEA2 ⊕ CSP
- Configuration of tests
- Methodology to tune SPEA2 ⊕ CSP
- Thèse L.I. Garcés Monge (2015-20xx)
- Collaboration P. Pitiot
Conclusion and Perspectives

- Validation
- Extraction
- Formalisation

- Configurateur
- CoFiADe

- Optimization & Configuration
- Validation our approach SPEA/two.pnum ⊕ CSP
- Configuration of tests
- Methodology to tune SPEA/two.pnum ⊕ CSP

- Thèse L.I. Garcés Monge (/two.pnum/zero.pnum/one.pnum/five.pnum-/two.pnum/zero.pnumxx)
- Collaboration P. Pitiot

- Interactivity & User
- Explanations
- Uninstantiation of Variables (depropagation)
- Values Preference
- ⇒ Guide for SPEA/two.pnum ⊕ CSP

- Configuration, Maturity & Risks
- Configuration (Technical Solution/Project)
- Evaluation (Maturity/Risks)

- Thèse A. Sylla (/two.pnum/zero.pnum/one.pnum/five.pnum-/two.pnum/zero.pnumxx)
- Collaborations ENI Tarbes et UniSA Adélaïde Australie
- Common Project in ORKID team

- Knowledge Life Cycle
- Inconsistencies Identification
- Reverse-engineering of field knowledge
- Interactivity & Filtering
- Knowledge Compilation
- Resolution
- Collaborative Configuration

- É. Vareilles (Mines Albi)
- HDR Presentation
Conclusion and Perspectives

- Configuration, Maturity & Risks

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  - Common Project in ORKID team
Conclusion and Perspectives

- Solution technique
- Project de réalisation

- Utilisateur

- Maturité
- Risque
- Performance
- Délai
- Coût

- Validation
- Extraction
- Formalisation

- CoFiADe

- Optimization & Configuration

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- Collaborative Configuration

- Common Project in IO & ORKID teams
**Conclusion and Perspectives**

- **Interactivity & User**
  - Explanations
  - Uninstantiation of Variables (depropagation)
  - Values Preference
    \[ \Rightarrow \text{Guide for SPEA2 } \oplus \text{ CSP} \]
Conclusion and Perspectives
Conclusion and Perspectives

Interactivity & Filtering

- Knowledge Compilation
- Resolution
Conclusion and Perspectives

- Utilisateur
- Maturité
- Risque
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Conclusion and Perspectives

Knowledge Life Cycle

- Inconsistencies Identification
- Reverse-engineering of field knowledge
Conclusion and Perspectives

- Utilisateur
- Maturité
- Risque
- Décalage
- Coût
- Coût
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- Validation
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- Knowledge Life Cycle
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- Reverse-engineering of field knowledge

- Knowledge Compilation
- Resolution
- Collaborative Configuration
- Common Project in IO & ORKID teams

- HDR Presentation
Conclusion and Perspectives

Collaborative Configuration
- Collaborative Configuration
- Common Project in IO & ORKID teams

Configurateur CoFiADe

Extraction Formalisation Validation

Interactivity & Filtering
Knowledge Compilation
Resolution

Knowledge Life Cycle
Inconsistencies Identification
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Thèse L.I. Garcés Monge (/two.pnum/zero.pnum/one.pnum/five.pnum-/two.pnum/zero.pnumxx)
Collaboration P. Pitiot

Thèse A. Sylla (/two.pnum/zero.pnum/one.pnum/five.pnum-/two.pnum/zero.pnumxx)
Collaborations ENI Tarbes et UniSA Adélaïde Australie
Common Project in ORKID team

Configuration (Technical Solution/Project)
Evaluation (Maturity/Risks)
Interactive Configuration and Constraints

Knowledge, Filtering algorithms and Extensions

Élise Vareilles
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Mines Albi
24th of November 2015