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State of CP Teaching - An Overview

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University College Cork, Cork, Ireland

Insight



SFI RESEARCH CENTRE FOR DATA ANALYTICS

August 24, 2023

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Overview

- Provide an overview of "State of CP Teaching"
- Results of short survey
- Overview of on-line courses
- Other resources
- Books
- How visible is CP to the wide world?

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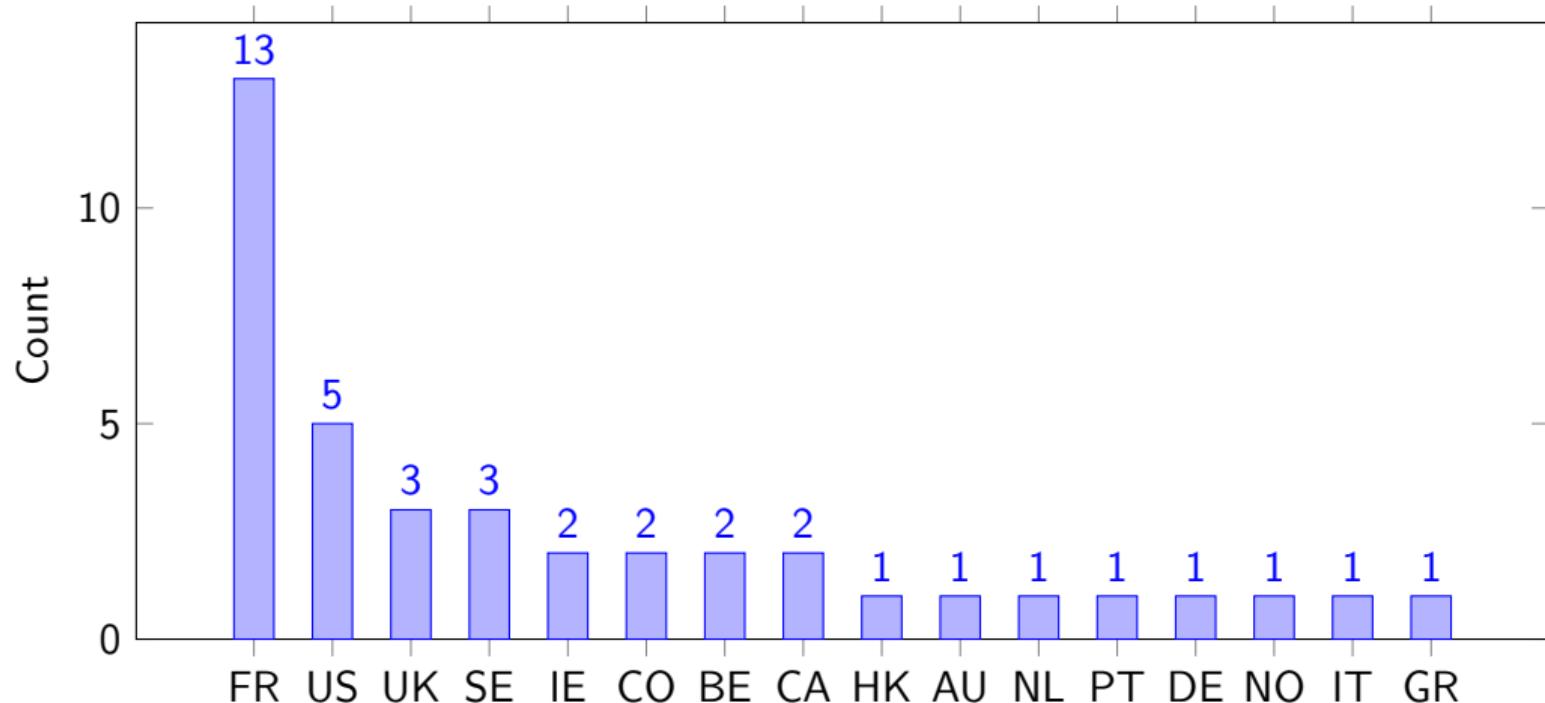
[Books](#)

[What does the world know about Constraint Programming?](#)

Results of Survey

- Google forms survey announced on August 10th
- Survey still open at <https://forms.gle/v54HUsbSXcyHmfME9>
- Emails sent to some members of community
- So far, 41 participants from 17 countries
- Focus on CP courses, perhaps widen scope
- Several participants run multiple courses

Participants by Country (Total = 41)



Institutions Covered

- France

- CRIL Lens
- Montpellier
- Grenoble
- Sophia Antipolis
- Nice
- Ecole Polytechnique
- IMT Nantes
- IMT Brest
- INRAE
- UPHF Valenciennes
- Gosling
- IRISA, Rennes
- INRIA

- Canada

- Laval
- Poly Montreal

- USA

- UT Dallas
- Brown
- CMU
- UConn
- City University New York

- UK

- Edinburgh
- York
- St Andrews

- Sweden

- Lund Univ
- RISE
- Upssala

- Belgium

- Louvain
- KU Leuven

- Germany

- Fraunhofer
- TU Cottbus

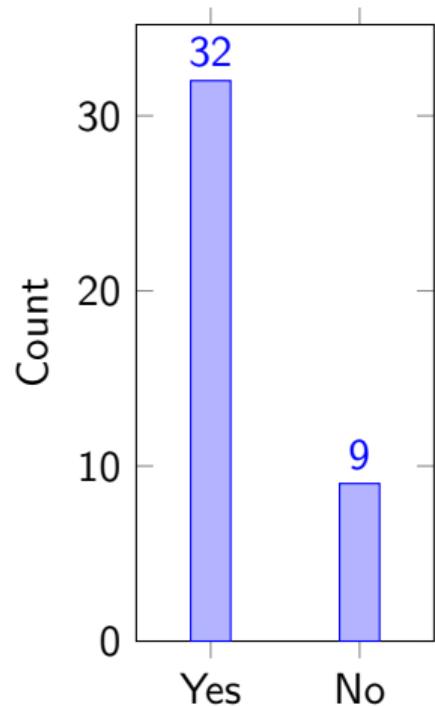
- Ireland

- MTU
- UCC

- Others

- UDG Girona, Spain
- CUHK, China
- Monash, Australia
- Delft, NL
- Lisbon, Portugal
- Bologna, Italy
- Simula, Norway
- Western Macedonia, Greece
- Universidad del Valle, Colombia

Does your institution offer a CP course?

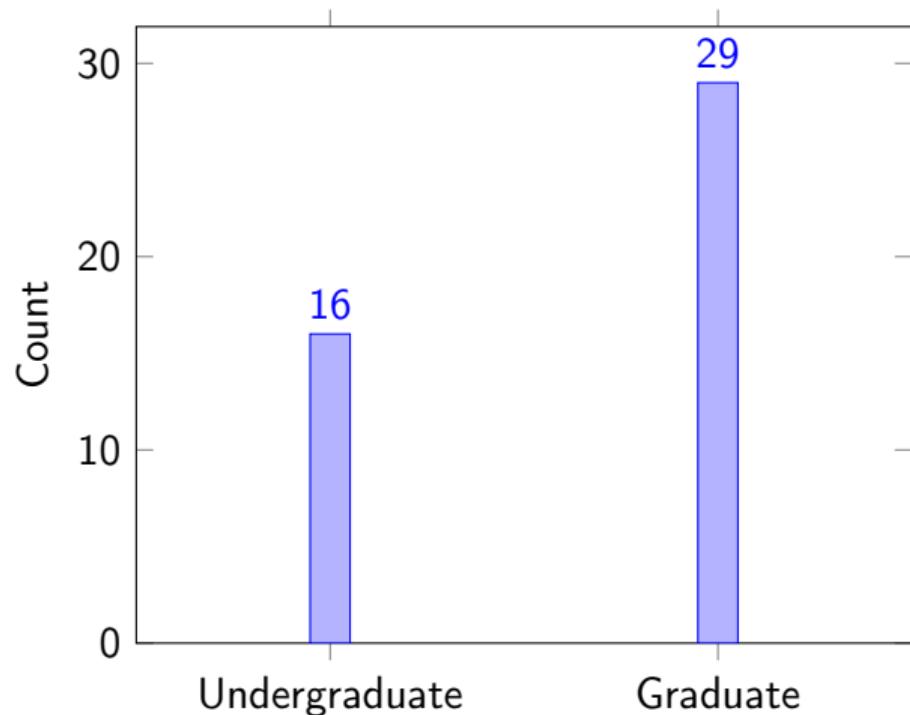


If not, why not (Total 9)?

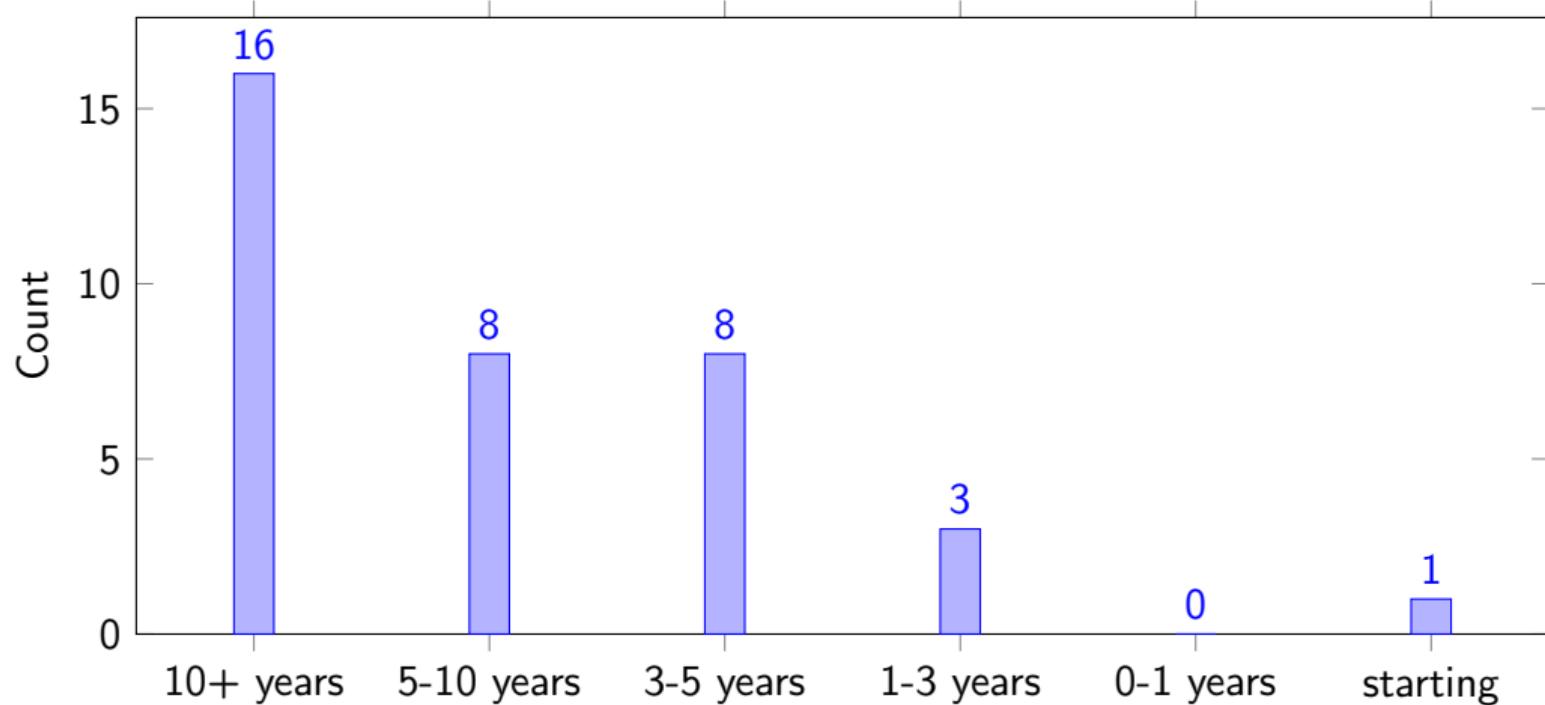
- (4) No students (industry, research centre)
- (2) Time/Workload
- (1) No interest by students
- (1) Not allowed by institution
- (1) CP is not a recommended course in the ACM Curricula Recommendations.

We did not receive any answer from industry running CP training.

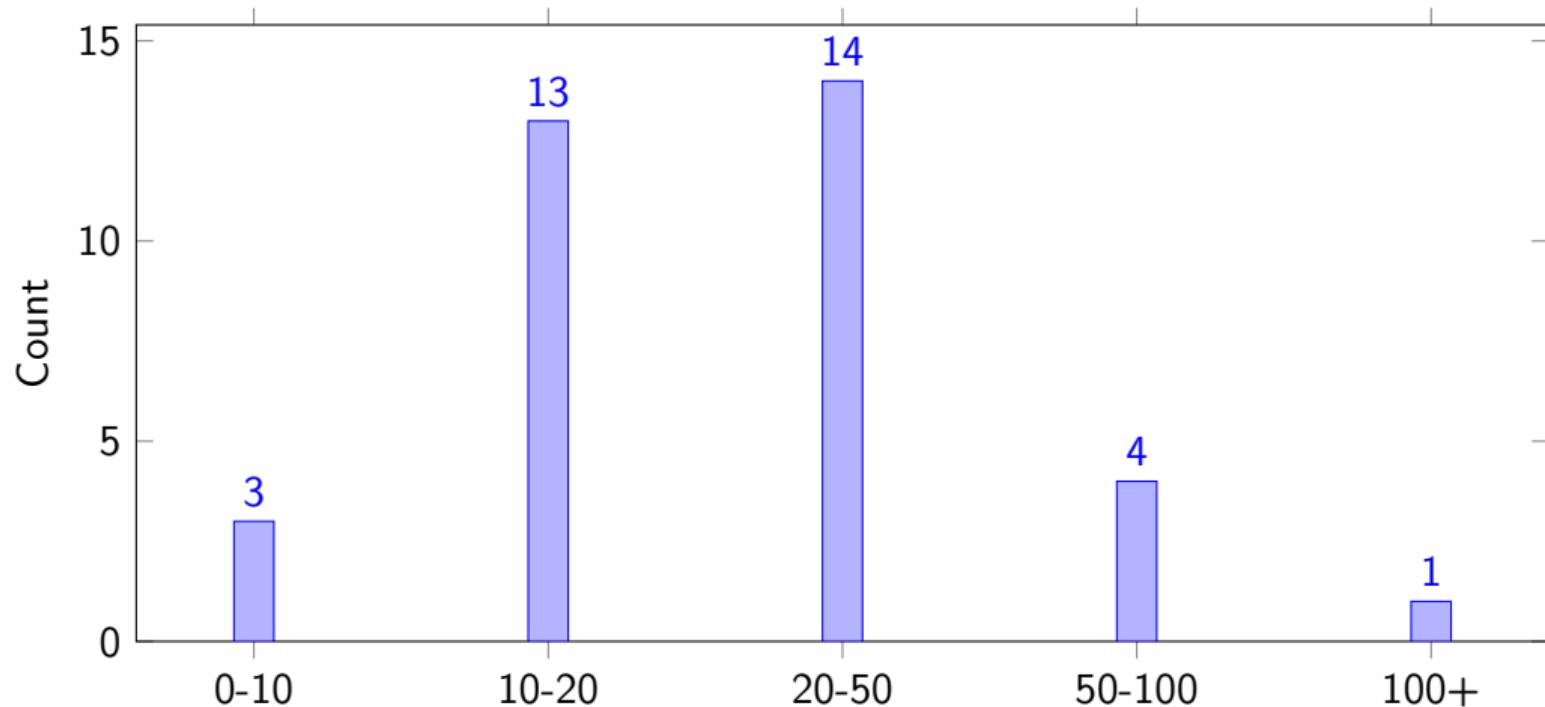
Audience (Multiple Allowed)



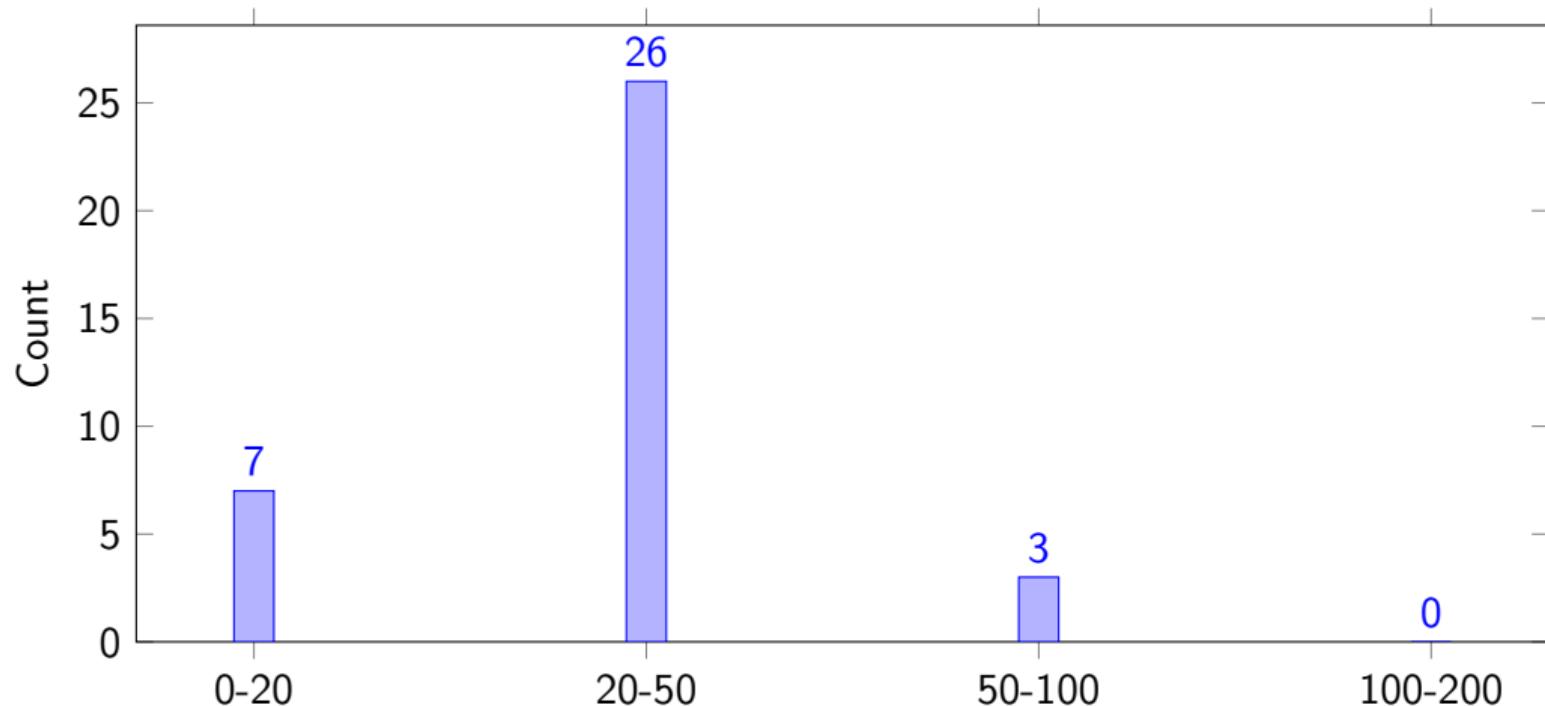
How long has the course been offered?



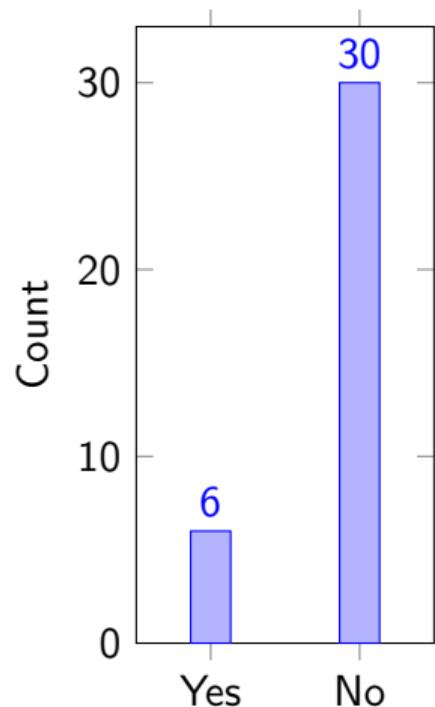
How many students does each offering of the course have?



How many hours of instruction does the course have?



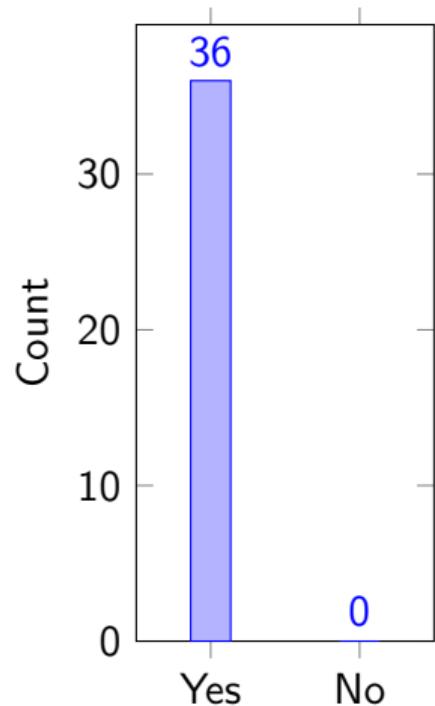
Does the class use a textbook or similar resource?



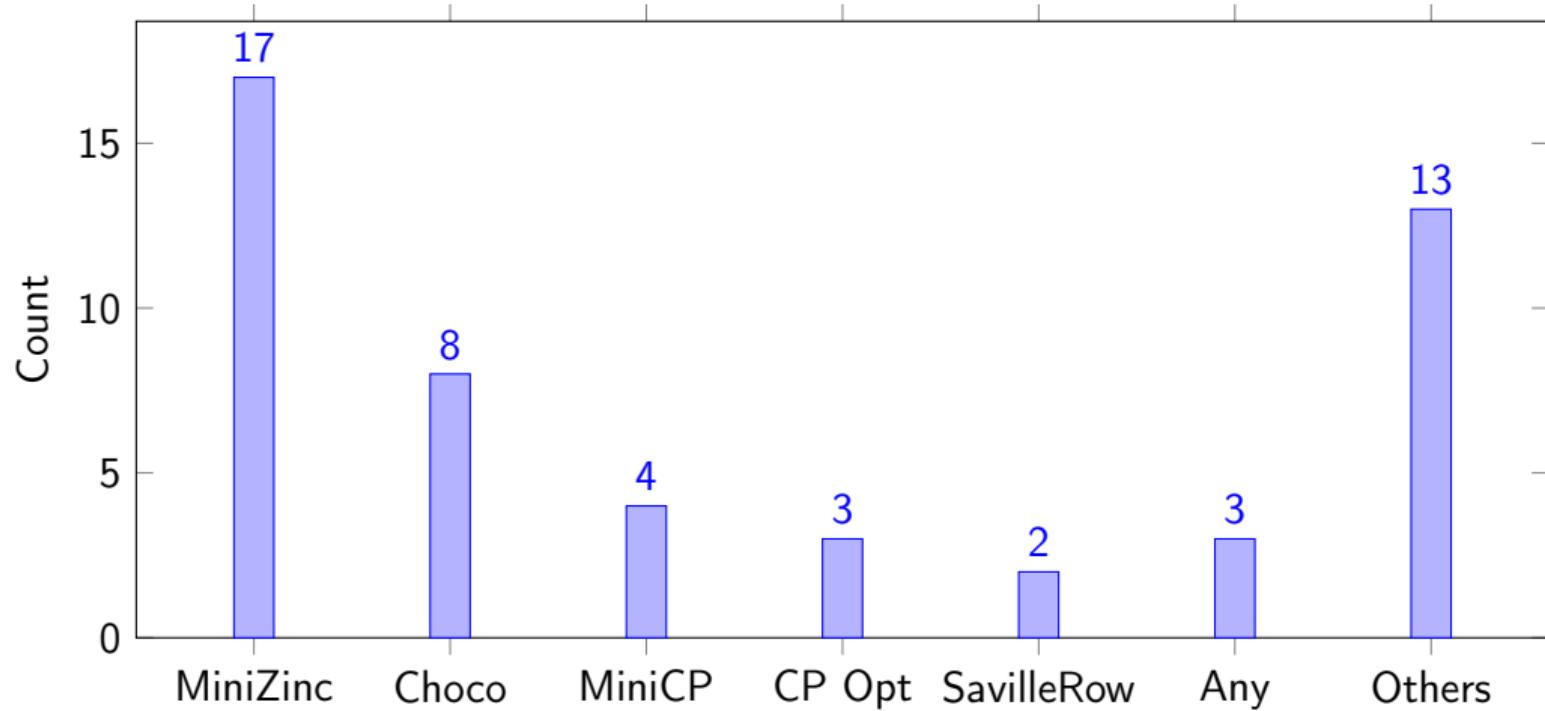
If yes, which resource is used? (Multiples Allowed)

- (2) Krzysztof Apt "Principles of Constraint Programming"
- Jupyter notebooks
- MiniZinc Handbook
- EdX MOOC
- MiniCP material
- Krzysztof Kuchcinski, "Modeling and Optimization of Embedded System with Constraint Programming: Principles and Practice"
- Global Constraint Catalog
- Choco manual
- Research papers

Does the class involve coding?



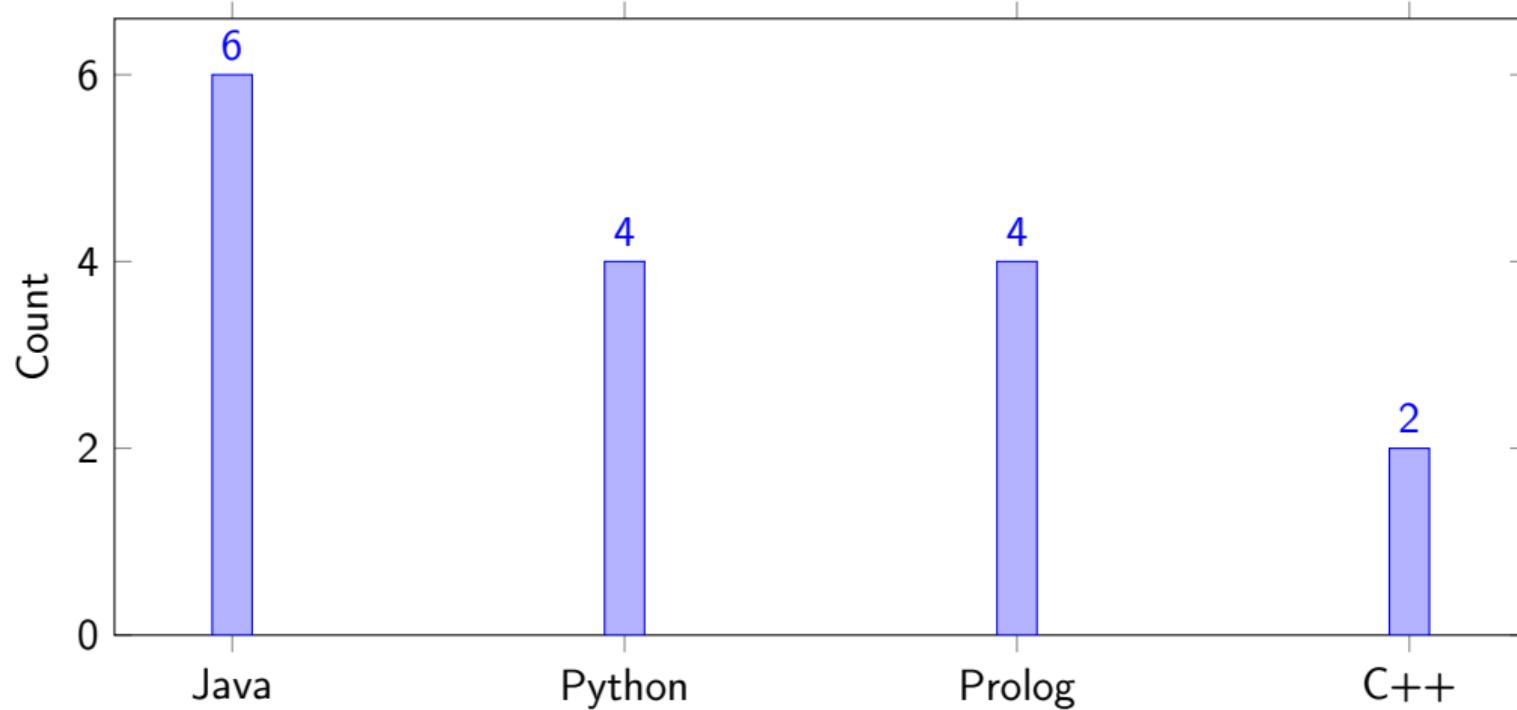
Solver/System Used? (Multiple Allowed)



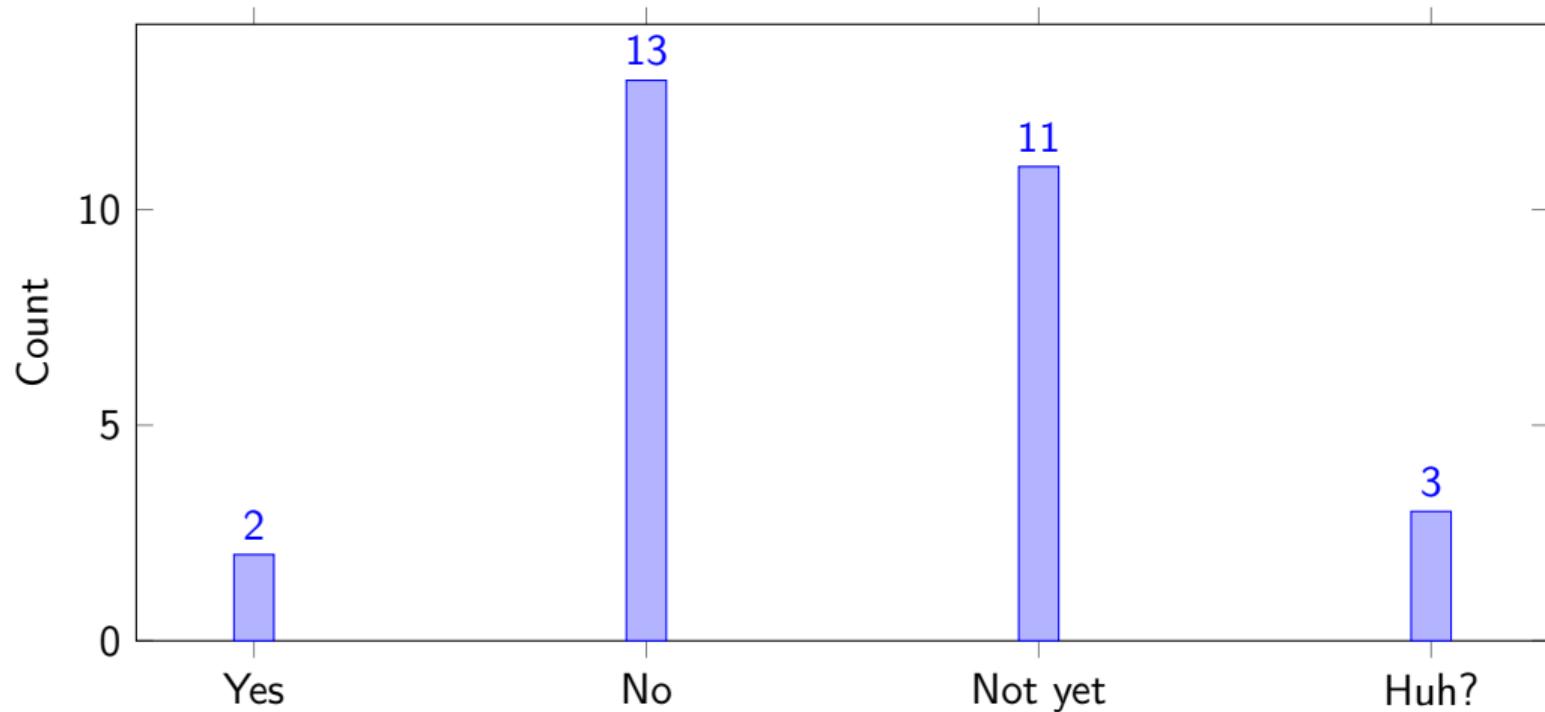
Other Solvers/Systems Named

- SICStus Prolog
- SAT
- Conjure
- PyCSP3
- pysat
- Z3
- Clingo
- Hava
- Z3
- Jacop
- SWI Prolog
- Essence'
- pytoolbar
- ECLiPSe

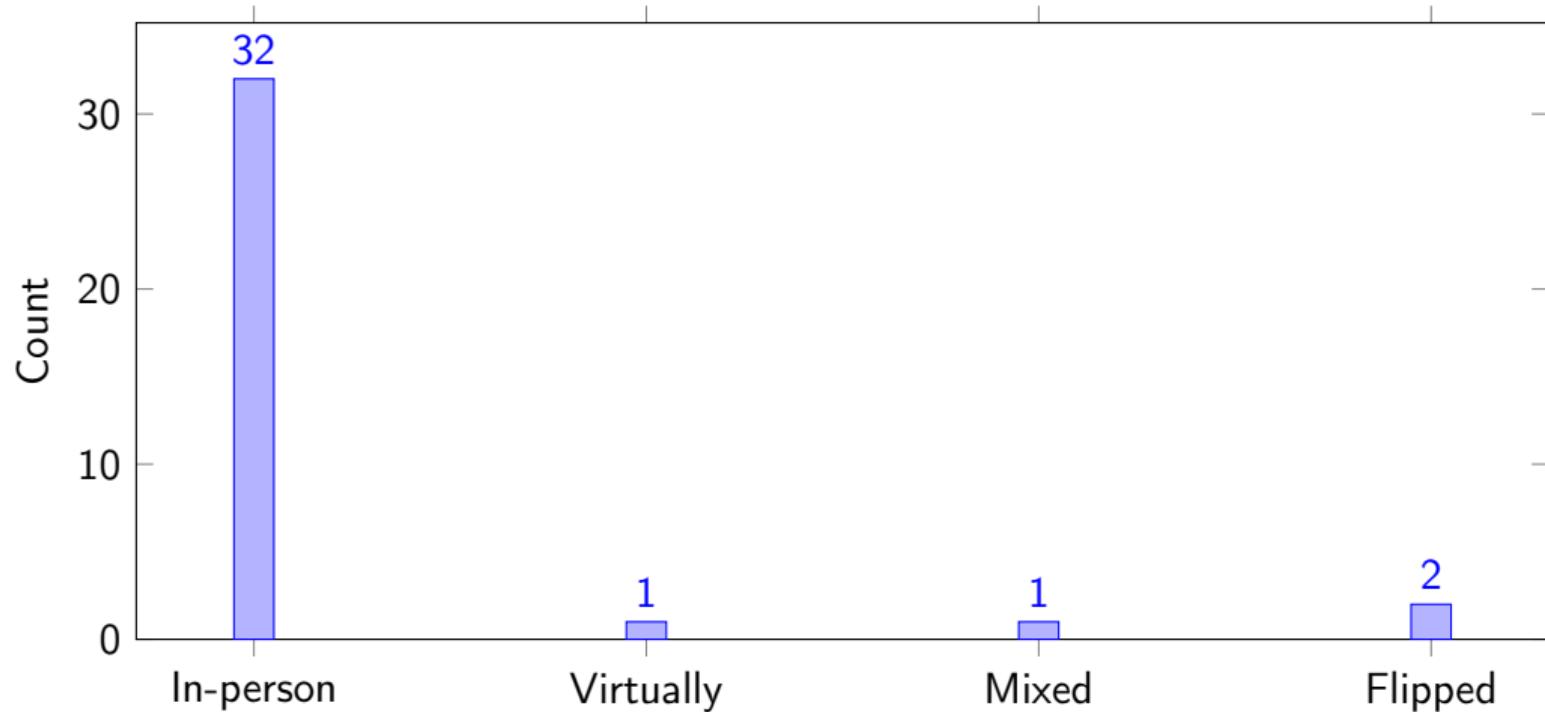
Programming Language Used? (Multiple Allowed)



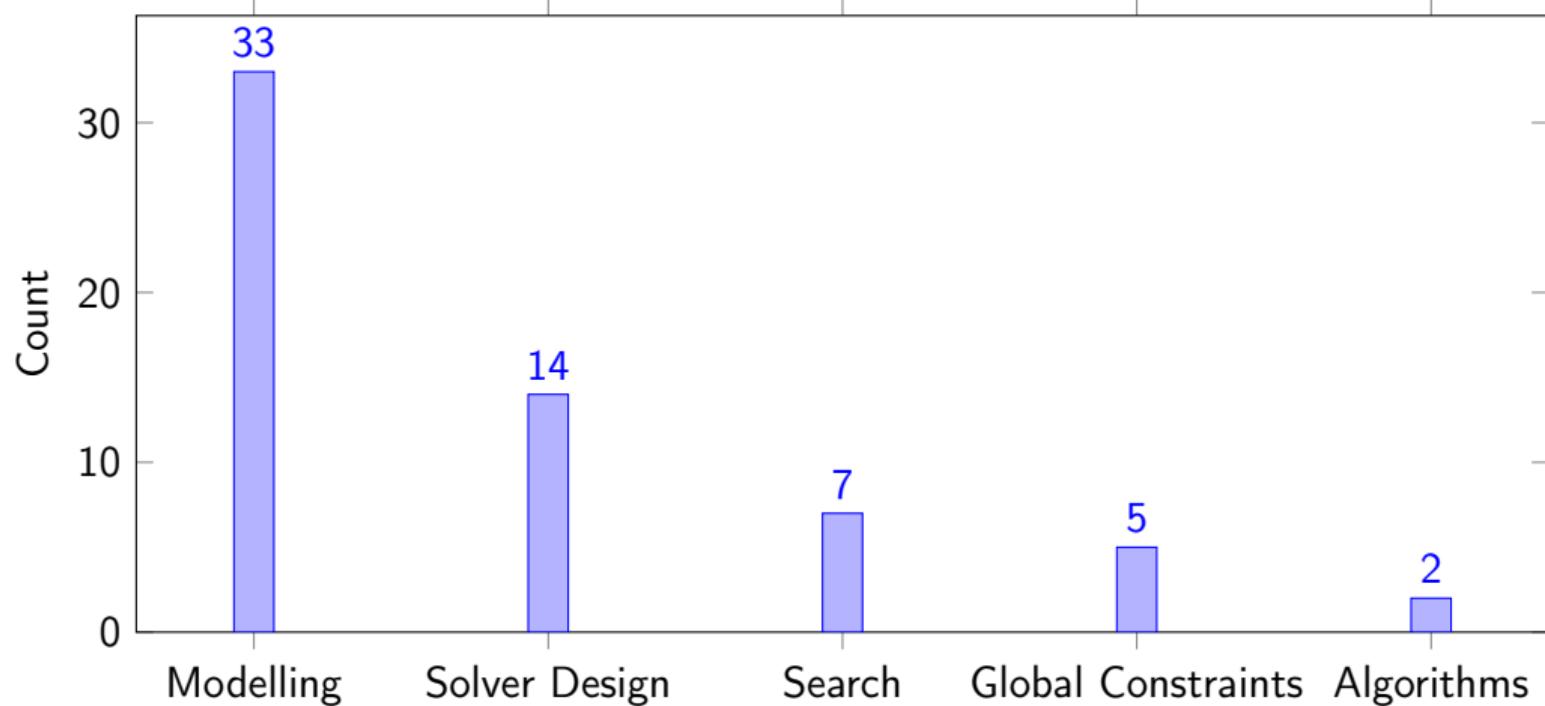
Have you seen any impact of Large Language Models (LLM)?



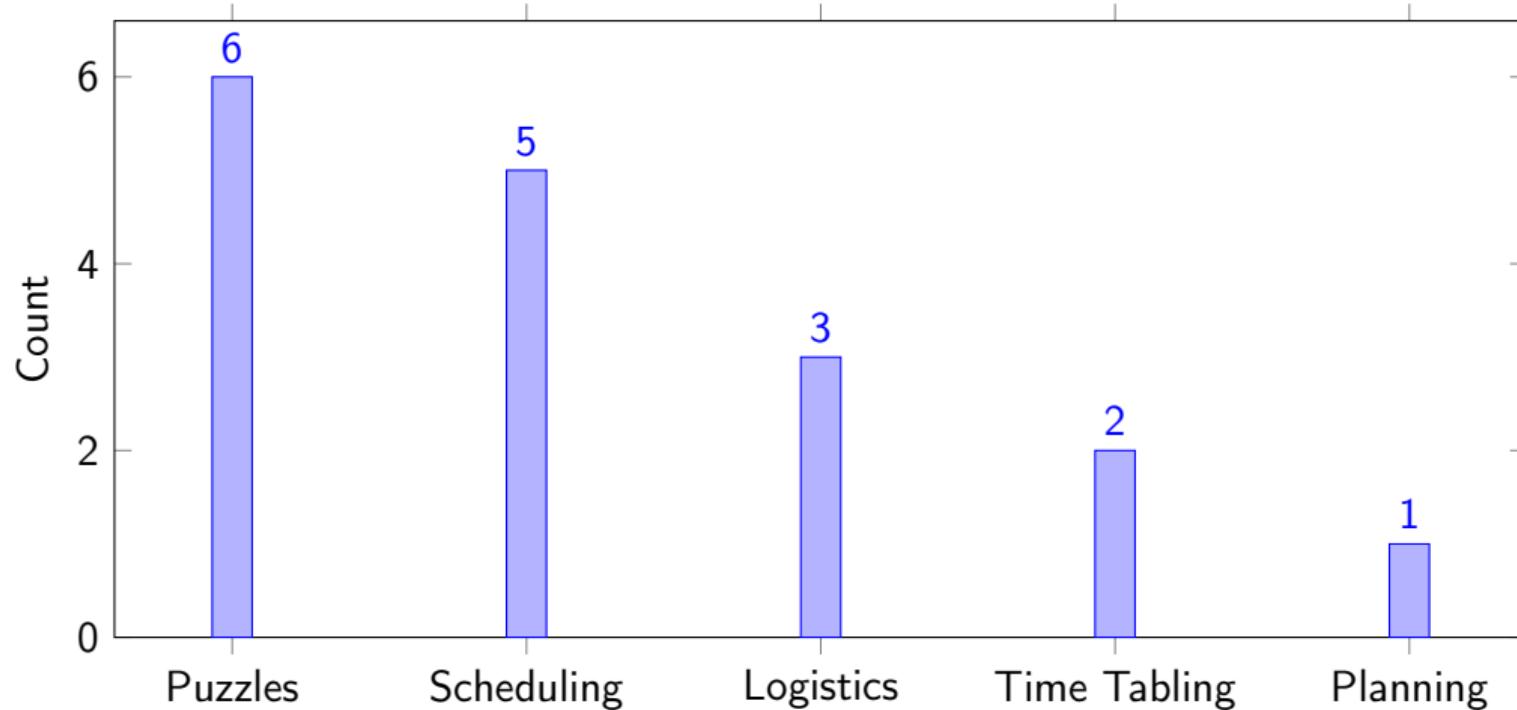
Is the instruction primarily delivered through in-person interaction or through videos/MOOC?



What sort of exercises do the students solve (Free Form, Areas)?



What sort of exercises do the students solve (Free Form, Problem Types)?



Comments (Selection)

- The course is pretty challenging for students without a lot of computational thinking, and since it doesn't have many direct prerequisites there are always a number of weak students who struggle a lot. Partly because we have a generation of weak students who complete assignments by a combination of LLM and reddit and trial and error!
- This is a timely workshop because the ACP EC is currently discussing the dissemination of CP through turnkey teaching modules that can be incorporated into university courses and through turnkey tutorials that can be proposed in related conferences.
- Prolog with appropriate constraint solving and constraint-based modeling libraries should be the right language to teach CP

Survey Summary

- Snapshot of current situation
- Notable systems missing (CP-SAT)
- How many courses are we missing?
- How do people learn CP outside the academic environment?
- Do you teach a CP course and are not on the list? Please fill in survey at
<https://forms.gle/v54HUsbSXcyHmfME9>
- Do you know about courses in other places? Talk to us!

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General Resource Pages

Summer Schools

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What does the world know about Constraint Programming?

Association for Constraint Programming (ACP)

- Main site of organization
- Formal description of rules and structure
- <https://www.a4cp.org/>

Home About the ACP Constraint Programming Events Awards Log In Join the ACP Contact

ACP Association for Constraint Programming

SEARCH

SUCCESS STORIES
A CP solver designs a self-assembling protein



Designing a stable and self-assembling protein requires to organize thousands of atoms in a favorable configuration in space.

[Read more...](#)

1 of 4 [next](#)

Welcome to the ACP

The Association for Constraint Programming aims at promoting constraint programming in every aspect of the scientific world, by encouraging its theoretical and practical developments, its teaching in the academic institutions, its adoption in the industrial world, and its use in the application fields.
[More about the ACP](#)

About Constraint Programming

We provide a number of resources for you to explore the history and the state of the art of all aspects of computing with constraints.

- Read about Success Stories of our field.
- The PhD thesis archive is an initiative to collect and archive PhD dissertations from the field of Constraint Programming.
- And the Quarterly Reports of the ACP executive committee.

ACP membership

If you are interested in becoming a member of the Association for Constraint Programming, sign up [here!](#)

There is also the community-run constraints google group mailinglist for announcements and more.

Upcoming Events

2023 ACP Summer School
The 2023 ACP Summer School, July 10th to 14th 2023, Leuven, Belgium. Website with more info.

CP2023
Twenty-Ninth International Conference on Principles and Practice of Constraint Programming. August 27th to 31st 2023, Toronto, Canada.

News

[ACP EC] CP 2023: Preliminary Schedule; Register now!
[ACP members] CP 2023: Preliminary Schedule; Register now!
[ACP members] CP2023 call for participation
[ACP members] CP 2023 DE Scholarship Bang! Mentoring
[ACP members] ACP Diversity, Equity Bang! Inclusion Surveys - 2023

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CP Resources Curated by E. Freuder

- Collection of many items related to CP
- Implemented using pearltrees
- <https://www.pearltrees.com/constraints/resources/id39817957>

Resources

Curator February 5, 2023 300 items 8.7K views comment

This is a collection of resources related to constraints: constraint programming, constraint-based reasoning, constraint satisfaction and optimization. It is a work in progress, which will probably always be "in progress". If you have suggestions for additions or changes, you can contact the curator. Read more

Curator

Learn

Demos

Puzzles & Games

Association for Constraint Programming

Online Discussion Groups

Research Groups

Conferences and Workshops

Solvers, Languages, Libraries

Connections to Other Fields

Applications

Companies

Journals

Books

Theses

Papers

Survey, Checklists, Bibliographies

Problems and Competitions

Tools

Videos

Photos

Media

Songs

History

Popcorn

On-line Courses

Courses

← ↑ +() 🔍 ⌂ ⌂

Constraints January 19, 2023 5 items 365 views comment

Pierre Schaus, Laurent Michel, Pascal Van Hentenryck



Pascal Van Hentenryck



Jimmy Ho Man Lee Peter Stuckey



Helmut Simonis



Online Learning Resources for Reasoning With Constraints chapter of Artificial...

From the Online Learning Resources page (<http://artint.info/2e/online.html>) at the website for ...

Link <https://www.pearltrees.com/constraints/courses/id39842792>

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What does the world know about Constraint Programming?

ACP Summer Schools

- Running yearly since 2005
- Typical one week course
- Research oriented
- For PhD students in the field
- <https://www.a4cp.org/events/summer-schools>

Home About the ACP Constraint Programming Events Awards Log In Join the ACP Contact

ACP Association for Constraint Programming

EVENTS

- CP-Conference Series
- ACP Summer Schools
- Competitions
- Call for Outreach Initiatives
- Diversity, Equity and Inclusion surveys

SEARCH

The Association of Constraint Programming is seeking to augment and complement University teaching of CP, and to disseminate a core body of CP knowledge supporting the recognition of CP as a mature and relevant technology for use in industry.

To help the CP community in these respects, the ACP Executive Committee has decided to start a series of CP summer schools to be held annually. The subject of each summer school will alternate between general and specific: one year the school will cover most of the CP areas while in the following year the school will focus on one subject of research within CP.

The list of previous ACP summer schools is as follows:

Year	Month	Venue	More Information
2023	July	Leuven, Belgium	web
2022	August	Hatia, Israel	web
2021	November/December	Online	web
2020	November	Toulouse, France	web
2019	July	Vienna, Austria	web
2018	June	Jackson, Wyoming, USA	web
2017	September	Ponquerolles, France	web
2016	June	Cork, Ireland	web
2015	July	Toronto, Canada	web
2014	June	Bologna, Italy	web
2013	January	Klaten, NSW, Australia	web
2012	September	Wrocław, Poland	web
2011	June	Turunc, Turkey	web
2010	May	Aussois, France	web
2009	June	Cork, Ireland	web
2008	June	St. Andrews, Scotland	web
2007	June	Lloret de Mar, Spain	web
2006	June	Santorini, Greece	web
2005	September	Maratissa, Italy	web

Summer School 2023 in Leuven/Belgium

- In July 2023
- Focus on ML and CP combination
- Lectures recorded, available on youtube
- <https://www.youtube.com/playlist?list=PLcByDTr7vRTYJ2s6DL-3bzjGwtQif33y3>

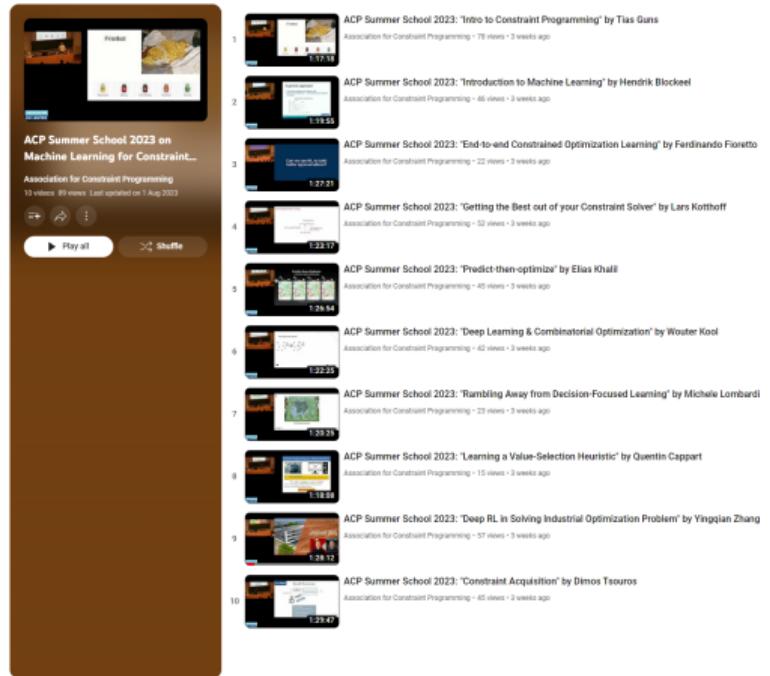


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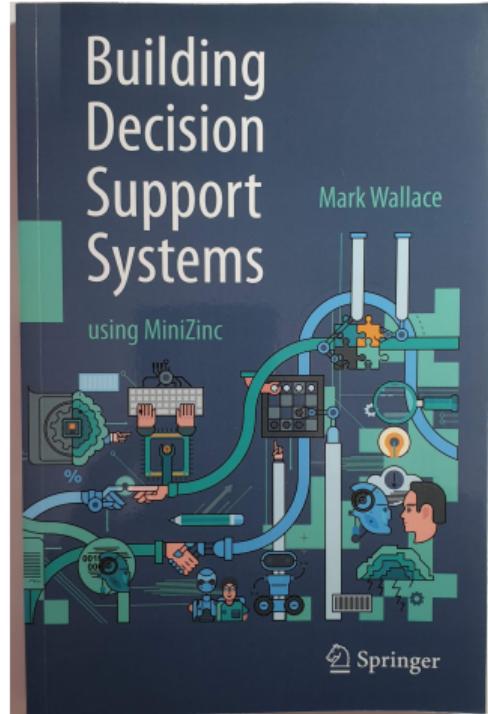
Summer Schools

Books

What does the world know about Constraint Programming?

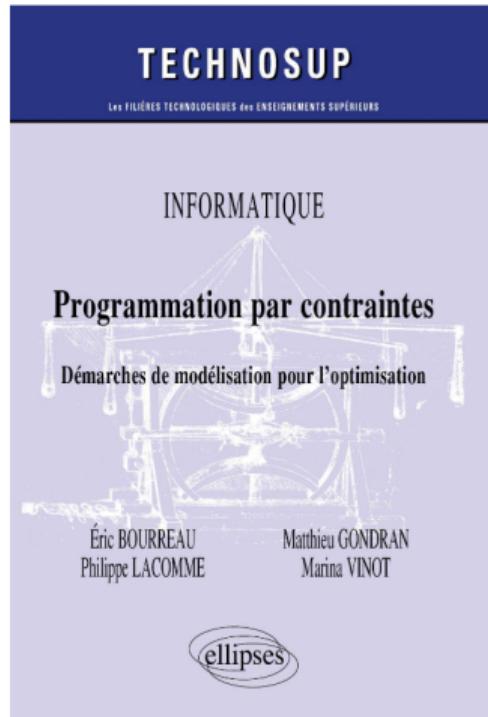
Building Decision Support Systems using MiniZinc

- Mark Wallace
- Springer, 2020
- Tool: MiniZinc
- ISBN: 978-3030417314



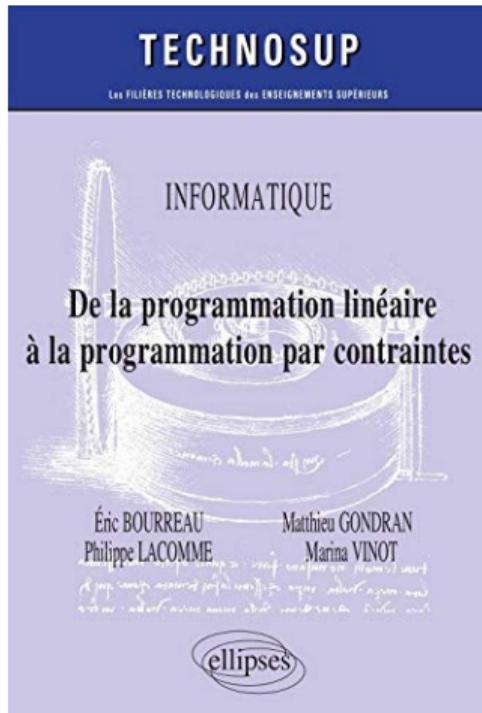
Programmation par Contraintes

- Eric Bourreau, Matthieu Gondran, Philippe Lacomme, Marina Vinot
- ellipses, 2020
- in French
- Tool: Choco
- ISBN: 978-2340035850



De la programmation linéaire à la programmation par contraintes

- Eric Bourreau, Matthieu Gondran, Philippe Lacomme, Marina Vinot
- ellipses, 2019
- in French
- Tool: Choco, Cplex
- ISBN: 978-2340029460



La programmation par contraintes et les raisonnements distribués

- Imade Benelallam
- Editions Universitaires
Europeennes, 2018
- in French
- ISBN: 978-6138424611

Ce livre est le résultat de notre travail de recherche qui s'articule autour de l'étude de la technologie contraintes. D'une part nous avons développé trois contributions dans le cadre des Problèmes DiscSPNs : AFC-AMAC (Asynchronous Forward Checking Agent) qui est un algorithme qui consiste à intégrer le concept de negocid dans le protocole AFC d'origine. AILFC (Asynchronous Inter Level Forward-Checking) : Dans cette méthode nous exploitons les caractéristiques du graphe de contraintes à travers une recherche asynchrone et parallèle. Ensuite, AMAC (Asynchronous Maintaining Agents Arc-Consistency AMAC) : Cette contribution consiste en la propagation des effets d'arc-inconsistance à travers les agents. D'autre part nous avons réalisé trois approches pour les Problèmes d'optimisation de Contraintes : ADFS (Asynchronous Breadth-First Search DCOP) : Cet algorithme consiste à transformer le problème de communication préférée à résoudre en un arbre Breadth-First Search (BFS). DisD8&B (Distributed Dynamic Branch and Bound) : Une nouvelle méthode pour l'ordonnancement dynamique des agents. Dylop (Dynamic Backtracking for DCOP) : Une version Asynchrone de l'algorithme DisD8&B.



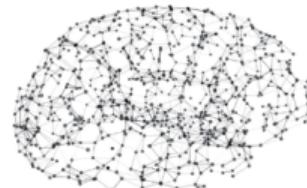
Imade BENELALLAM est un chercheur en Intelligence Artificielle, spécialisé en Programmation Par Contraintes. Actuellement, il est Professeur Habilité en IA, membre Senior à l'IEEE et Directeur du Laboratoire S2IM à Institut National de Statistique et d'Economie Appliquée de Rabat, Maroc.



978-613-8-42461-1

La Programmation Par Contraintes (PCC)

EUE
EDITIONS
UNIVERSITAIRES
EUROPEENNES



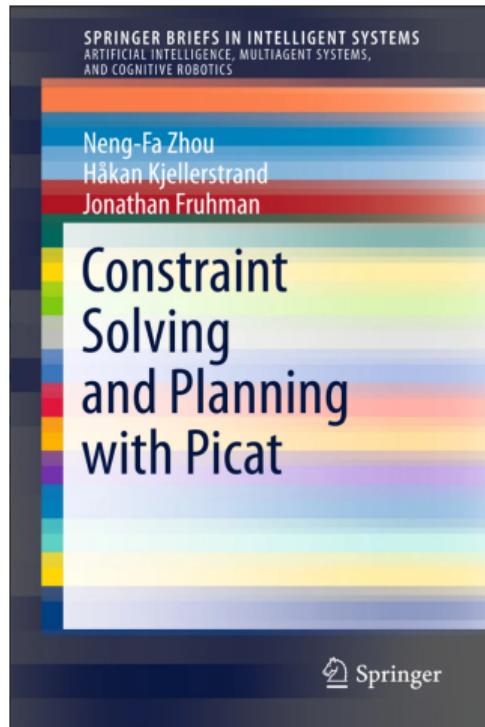
Imade Benelallam

**La programmation par
contraintes et les
raisonsnements distribués**

Pour la résolution des problèmes de
satisfaction et d'optimisation de contraintes

Constraint Solving and Planning with Picat

- Neng-Fa Zhou, Håkan Kjellerstrand,
Jonathan Fruhman
- Springer, 2015
- Tool: Picat
- ISBN: 978-3319258812



Integrated Methods for Optimization

- John Hooker
- Springer, 2011
- 2nd Edition
- ISBN: 978-1461418993

International Series in
Operations Research & Management Science

John N. Hooker

Integrated Methods for Optimization

Second Edition



Springer

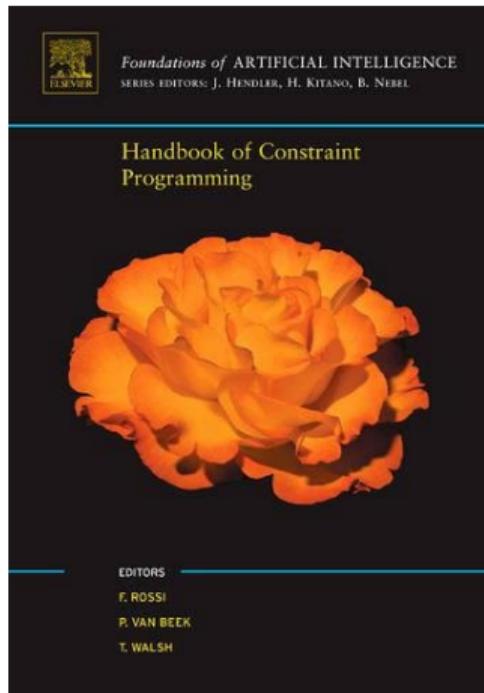
Einführung in die Constraint-Programmierung

- Petra Hofstedt, Armin Wolf
- Springer, 2007
- Tool:
- in German
- ISBN: 978-3-540-23184-4



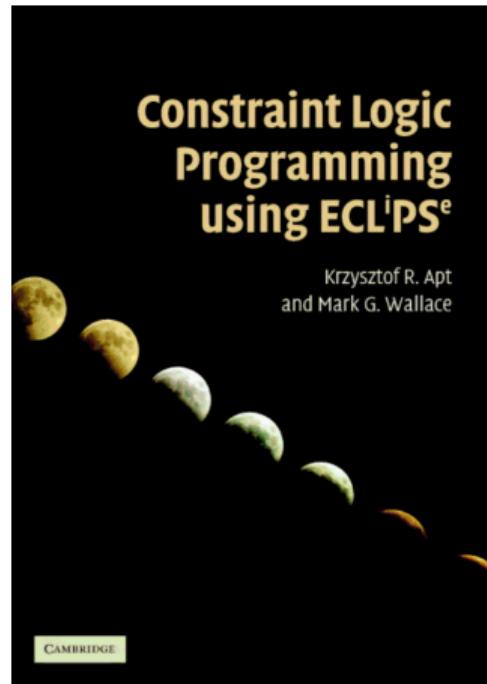
Handbook of Constraint Programming

- Francesca Rossi, Peter van Beek, Toby Walsh
- Elsevier, 2007
- Collection of Chapters
- ISBN: 978-0444527264



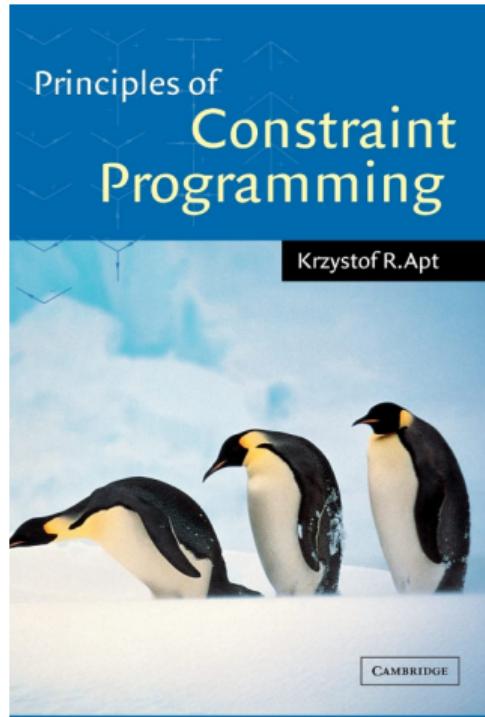
Constraint Logic Programming using ECLiPSe

- Krzysztof Apt, Mark Wallace
- Cambridge University Press, 2006
- Tool: ECLiPSe
- ISBN: 978-0521866286



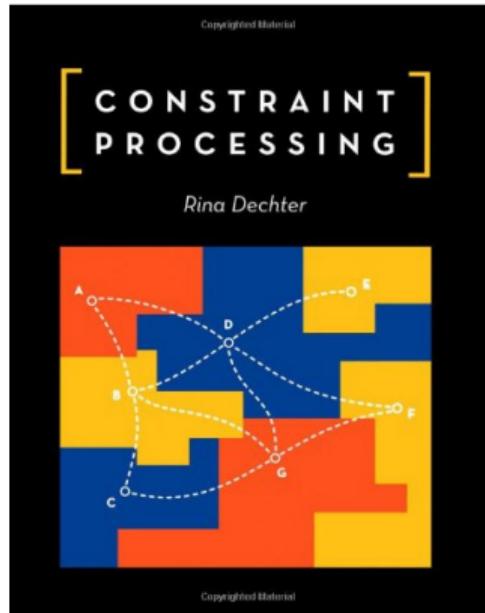
Principles of Constraint Programming

- Krzysztof Apt
- Cambridge University Press, 2003
- ISBN: 978-0521825832



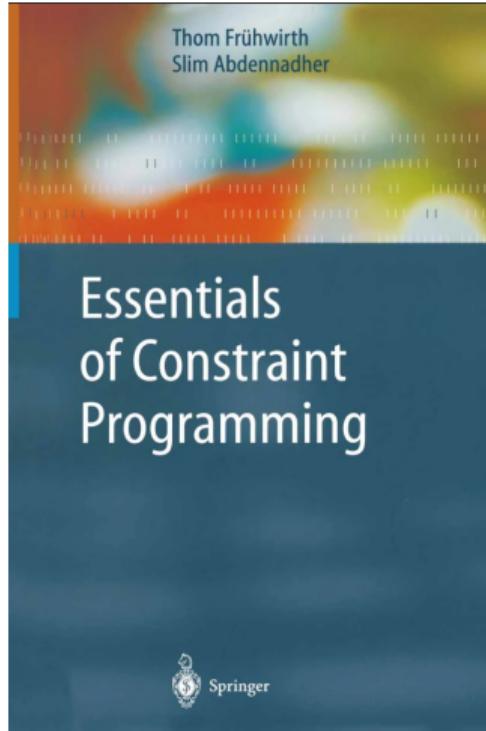
Constraint Processing

- Rina Dechter
- Morgan Kaufmann, 2003
- ISBN: 978-1558608900



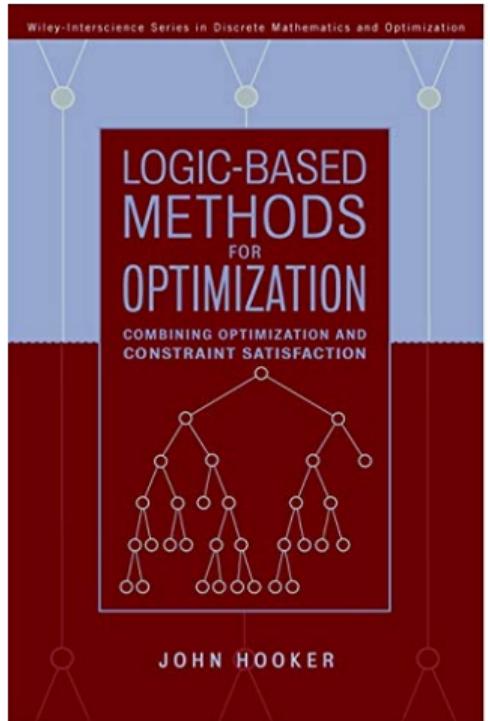
Essentials of Constraint Programming

- Thom Frühwirth, Slim Abdenader
- Springer, 2003
- ISBN: 978-3540676232



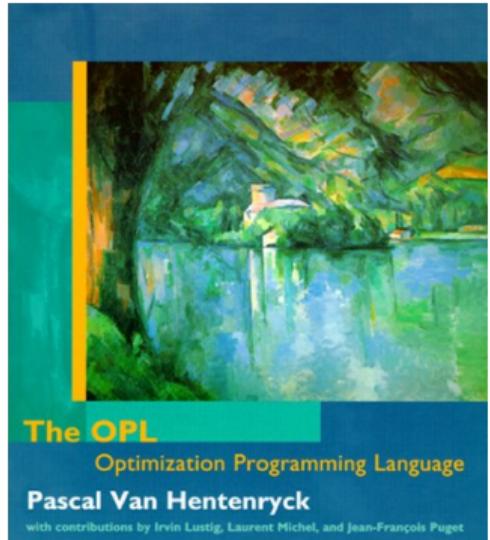
Logic-Based Methods for Optimization: Combining Optimization and Constraint Satisfaction

- John Hooker
- Wiley, 2000
- ISBN 978-0-471-38521-9



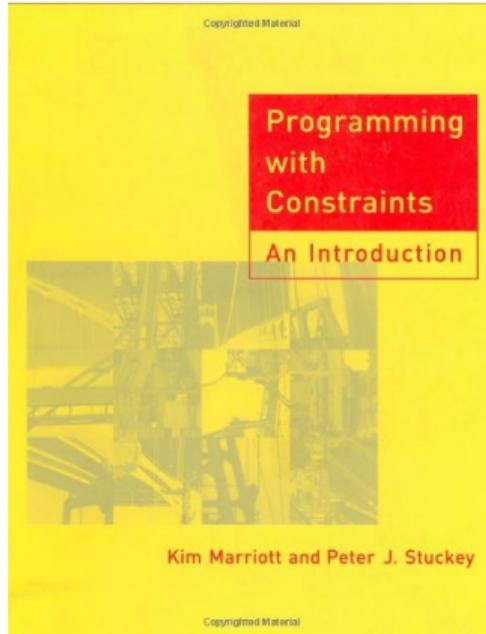
The OPL Optimization Programming Language

- Pascal Van Hentenryck
- MIT Press, 1999
- Tool: OPL
- 978-0262720304



Programming with Constraints

- Kim Marriott, Peter Stuckey
- MIT Press, 1998
- Tool: CLP(R)
- 978-0262133418

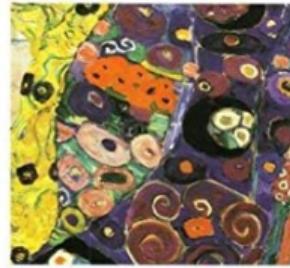


Programmation logique par contraintes

PROGRAMMATION
LOGIQUE
PAR CONTRAINTES

François Fages

- Francois Fages
- ellipses, 1998
- in French
- ISBN: 978-2729846138



Constraint Satisfaction in Logic Programming

- Pascal Van Hentenryck
- MIT Press, 1989
- Tool: CHIP
- ISBN: 978-0262081818

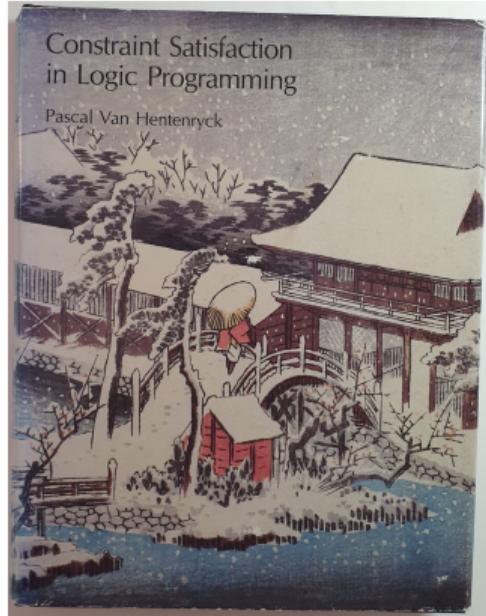


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What does the world know about Constraint Programming?

Constraint Programming



Images

Videos

Examples

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C++

Tutorial

Solver

All filters ▾ | Tools

About 166,000,000 results (0.44 seconds)

The key idea of constraint programming (CP) is that it uses constraints to reduce the set of values that each variable can take. In CP, the program (or solver) keeps track of values that can appear. After every move, the search space is pruned. This means that the values that can't happen anymore are removed.

12 Jan 2023



Towards Data Science

<https://towardsdatascience.com/constraint-programmin...> ::

[Constraint Programming Explained - Towards Data Science](#)



>About featured snippets · Feedback



Wikipedia

https://en.wikipedia.org/wiki/Constraint_programming ::

[Constraint programming](#)

Constraint programming (CP) is a paradigm for solving combinatorial problems that draws on a wide range of techniques from artificial intelligence, ...

[Constraint logic programming](#) · [Constraint satisfaction problem](#) · [Constraint solving](#)

People also ask ::

Where is constraint programming used? ▾

What is constraints in programming questions? ▾

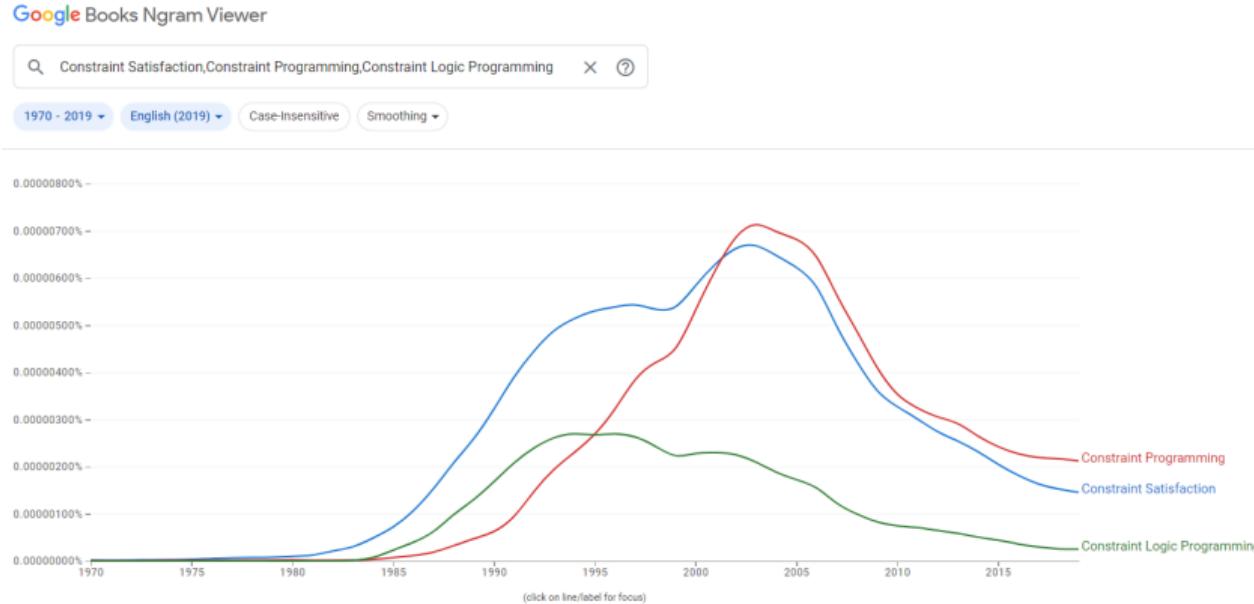
What is a constraint in machine learning? ▾

Constraint programming <

Constraint programming is a paradigm for solving combinatorial problems that draws on a wide range of techniques from artificial intelligence, computer science, and operations research. In constraint programming, users declaratively state the constraints on the feasible solutions for a set of decision variables.
[Wikipedia](#)

Feedback

Google NGram Viewer



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Constraint optimization problem

Perturbation vs refinement models

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Local Search

Dynamic programming

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External links

Constraint programming

16 languages ▾

Article Talk

Read Edit View history Tools ▾

From Wikipedia, the free encyclopedia



This article possibly contains original research. Please improve it by verifying the claims made and adding inline citations. Statements consisting only of original research should be removed. (June 2011) (Learn how and when to remove this template message)

Constraint programming (CP)^[1] is a paradigm for solving combinatorial problems that draws on a wide range of techniques from artificial intelligence, computer science, and operations research. In constraint programming, users declaratively state the constraints on the feasible solutions for a set of decision variables. Constraints differ from the common primitives of imperative programming languages in that they do not specify a step or sequence of steps to execute, but rather the properties of a solution to be found. In addition to constraints, users also need to specify a method to solve these constraints. This typically draws upon standard methods like chronological backtracking and constraint propagation, but may use customized code like a problem-specific branching heuristic.

Constraint programming takes its root from and can be expressed in the form of constraint logic programming, which embeds constraints into a logic program. This variant of logic programming is due to Jaffar and Lassez^[2] who extended in 1987 a specific class of constraints that were introduced in Prolog II. The first implementations of constraint logic programming were Prolog III, CLP(R), and CHIP.

Instead of logic programming, constraints can be mixed with functional programming, term rewriting, and imperative languages. Programming languages with built-in support for constraints include Oz (functional programming) and Kaleidoscope (imperative programming). Mostly, constraints are implemented in imperative languages via constraint solving toolkits, which are separate libraries for an existing imperative language.

Constraint logic programming [edit]

Main article: Constraint logic programming

Constraint programming is an embedding of constraints in a host language. The first host languages used were logic programming languages, so the field was initially called constraint logic programming. The two paradigms share many important features, like logical variables and backtracking. Today most Prolog implementations include one or more libraries for constraint logic programming.

Programming paradigms

- Action
- Array-oriented
- Automata-based
- Concurrent computing
 - Actor-based
 - Choreographic programming
 - Multi-tier programming
 - Relativistic programming
 - Structured concurrency
- Data-driven
- Data-oriented
- Declarative (contrast: imperative)
 - Functional
 - Functional logic
 - Purely functional
 - Logic
 - Abductive logic
 - Answer set
 - Concurrent logic
 - Functional logic
 - Inductive logic
 - Constraint
 - Constraint logic
 - Concurrent constraint logic
 - Dataflow
 - Flow-based
 - Reactive

youtube

Constraint Programming

All Shorts Unwatched Watched For you Recently uploaded Live About these results ⓘ Filters 🔍

Solving Combinatorial Optimization Problems with Constraint Programming and OscaR
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UCLouvain - Université catholique de Louvain
Prof. Pierre Schaus introduces Constraint Programming and the OscaR platform developed in his research team that he used to ...
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An Introduction To Constraint Programming - Jacob Allen
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HackSoc
As a programmer, computer scientist, computer engineer etc. there are many problems for which an algorithm can easily be ...
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Louis-Martin Rousseau: "Combining Reinforcement Learning & Constraint Programming for Combinator..."
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Institute for Pure & Applied Mathematics (IPAM)
Deep Learning and Combinatorial Optimization 2021 "Combining Reinforcement Learning and Constraint Programming for ...
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General Principles of Constraint Programming
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Microsoft Research
Constraint programming (CP) is a general and powerful method to solve some combinatorial problems. This method has been ...

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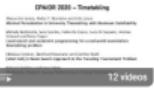
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Summary

- We presented an overview of Teaching Constraint Programming
- Survey results from 41 participants, 17 countries
- General resources for online courses, books
- Limited presence of CP in public space
- How can we do better?