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An improved constrained differential evolution using discrete variables (D-ICDE) for layout optimization of truss structures

Ho-Huu, V.; Nguyen-Thoi, T.; Nguyen-Thoi, M. H.; Le-Anh, L.. **Expert Systems with Applications** 42.20: 7057-69. Elsevier B.V. (Nov 15, 2015)

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AB **Abstract (summary)** [Translate](#)

Recently, an improved ($\mu + \lambda$) constrained differential evolution (ICDE) has been proposed and proven to be robust and effective for solving constrained optimization problems. However, so far, the ICDE has been developed mainly for continuous design variables, and hence it becomes inappropriate for solving layout truss optimization problems which contain both discrete and continuous variables. This paper hence fills this gap by proposing a novel discrete variables handling technique and integrating it into original ICDE to give a so-called Discrete-ICDE (D-ICDE) for solving layout truss optimization problems. Objective functions of the optimization problems are minimum weights of the whole truss structures and constraints are stress, displacement and buckling limitations. Numerical examples of five classical truss problems are carried out and compared to other state-of-the-art optimization methods to illustrate the reliability and effectiveness of the proposed method. The D-ICDE's performance shows that it not only successfully handles discrete variables but also significantly improves the convergence of layout truss optimization problem. The D-ICDE is promising to extend for determining the optimal solution of other structural optimization problems which contain both discrete and continuous variables. [All rights reserved Elsevier].

References

- RF** C. Camp, B. Bichon, Design of space trusses using ant colony optimization. *Journal of Structural Engineering*. 130 (2004) 10.1061/(ASCE)0733-9445(2004)130:5(741)
- T. Y. Chen, H. C. Chen, Mixed-discrete structural optimization using a rank-niche evolution strategy. *Engineering Optimization*. 41 (2008) 10.1080/03052150802344535
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- D. Datta, J. R. Figueira, A real-integer-discrete-coded particle swarm optimization for design problems. *Applied Soft Computing*. 11 (2011) 10.1016/j.asoc.2011.01.034

 **Indexing (details)**  **Cite**

SU, SUBT	Subject	buckling; evolutionary computation; optimisation; structural engineering; supports
CC	Classification	E2110A: General shapes and structures (major); E2180C: Buckling and instability (mechanical engineering); E0210G: Optimisation
IPC	IPC classification	E04C 3/00: Structural elongated elements designed for load-supporting; F16M: Frames, casings, or beds, of engines or other machines or apparatus, not specific to an engine, machine, or apparatus provided for elsewhere; Stands or supports
IF	Identifier (keyword)	discrete variables, layout optimization, truss structures, improved constrained differential evolution, D-ICDE, discrete variables handling technique, stress, displacement, buckling
TI	Title	An improved constrained differential evolution using discrete variables (D-ICDE) for layout optimization of truss structures
AU AUFN AULN	Author	Ho-Huu, V. ¹ ; Nguyen-Thoi, T. ¹ ; Nguyen-Thoi, M. H. ¹ ; Le-Anh, L. ¹ ¹ Div. of Comput. Math. & Eng. (CME), Ton Duc Thang Univ., Ho Chi Minh City, Ton Duc Thang University, Division of Computational Mathematics and Engineering (CME), Ho Chi Minh City, Vietnam hohuuvinh@tdt.edu.vn; nguyenthotrung@tdt.edu.vn; nguyenthomyhanh@tdt.edu.vn; leanhlinh@tdt.edu.vn
LA	Language	English
SL	Language of abstract	English
DTX	Document treatment	P, Practical, T, Theoretical or Mathematical
DTYPE	Document type	Journal Paper
PUB	Publication title	Expert Systems with Applications
VO	Volume	42
ISS	Issue	20
PG	Pagination	7057-69
ISSN	ISSN	0957-4174
CODEN	CODEN	ESAPEH
PSTYPE	Publication type	Journal Paper
PB	Publisher	Elsevier B.V.
PBLOC	Publisher location	Netherlands
FSU	Subfile	Mechanical and Production Engineering
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PD, YR	Publication date	Nov 15, 2015
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FAV	Copyright	2015 The Institution of Engineering and Technology
	First available	2015-06-25
	Updates	2015-06-25
UD	Database	Inspec® (1898 - current)

Search fields

Field Name	Field Code	Example	Description and Notes
Abstract	AB	ab("truss optimization" PRE/6 "continuous variables")	Use adjacency and/or Boolean operators to narrow search results.
Abstract present	ABANY	"evolutionary computing " AND abany(yes)	Add: <i>AND ABANY(YES)</i> to a query to limit retrieval to records with abstracts.
Accession number	AN	an(15204281)	A unique document identification number assigned by the information provider.
All fields + text	--	icde N/10 optimization nguyen AND "ho-huu"	Searches all fields except cited references.
Astronomical object indexing	ASI	asi("ngc 3393") asi(3393) asi("iras 18264-1152" OR "iras 05358+3543") asi("18264-1152" OR "05358+3543")	Available in some records added since 1995.
Author ¹ Author First Name Author Last Name	AU AUFN AULN	au("nguyen thoi, t") aufn(nguyen) auln(thoi)	Includes all Author names.
First author	FAU	fau("ho huu, v")	First name listed in Author field. It is included in Author <i>Browse field</i> , but its position cannot be specified there.
Author affiliation	AF	af("ton duc thang" AND vietnam)	Includes as much data as is available in the original document, such as organization, department, address, city, state, country, author email, etc.
Chemical indexing	CI	ci("si-al-au int") ci("ce - el") ci("si - int" AND "si - el") ci(fe AND si) ci(gaas bin)	Displays with label Substance. Available in some records added since 1987; CI searches both the substance(s) and/or role(s). Refer to <i>Chemical Indexing Roles</i> below. See also Substance.
Cited references	RF	rf("d data" LNK "applied soft computing" LNK 2011) rf(camp AND chen AND data) rf((datta LNK "applied soft computing" LNK 2011) AND (chen LNK "engineering optimization" LNK 2008))	Cited reference data is present in fewer than 10% of records in Inspec. References are displayed in the Abstract field. The content of references differ based on the type of work cited. For a journal reference, the cited author name(s), article title, publication title, volume, publication year, and DOI are typically given. Use LNK to explicitly search multiple parts of the same reference.

Field Name	Field Code	Example	Description and Notes
			Use AND if you want to search for multiple references within a single record.
Number of cited references	NR	nr(31)	
Classification ¹	CC	cc(E2180*) cc("buckling and instability")	Also searchable using field code INSPCC.
Major classification ¹	MJCC	mjcc("general shapes") mjcc(E2110A)	Displays in Classification field.
Classification (IPC) ¹	IPC	ipc(E04C 3/00) ipc(F16M) ipc(E04C 3/00: Structural elongated elements)	Available in records added since 1969. See below for more information.
CODEN	CD	cd(esapeh)	
Conference information	CF	cf("xii international scientific colloquium")	
Conference country	CNT	cnt(brazil)	
Conference event end date	EVDT	evdt(20110805)	Range searching is NOT supported for conference dates.
Conference event start date	ESDT CDT	cdt(20110731)	Range searching is NOT supported for conference dates.
Conference location	CG	cg("san jose, ca")	
Conference title	CFTI	cfti(2011 AND "neural networks")	
Digital object identifier	DOI	doi("10.1016/j.eswa.2015.04.072")	Search the portion of the DOI that comes after http://dx.doi.org/ . Video presentations at the IET Web site are linked from some documents. To locate them, add the query: doi(iet.tv) to your search.
Document title	TI	ti(optimization AND "truss structure*")	Includes Title, Alternate title and Subtitle, but not Publication title (PUB).
Title only	TIO	tio("truss structure*")	Searches only the Title, not Subtitle or Alternate title.
Document treatment	DTX	dtx(p) dtx(practical) dtx(x AND t) dtx(experimental AND theoretical)	First used in 1971. Multiple treatment codes may apply to a single document.
Document type	DTYPE	dtype(journal PRE/1 paper*) dtype("conference paper") dtype(report NOT "report section")	
Editor	ED	ed("smith, j*")	
First available	FAV	fav(20131212)	Indicates the first time a document was loaded in a specific database on Dialog. It will not change regardless of how many times the record is subsequently reloaded - as long as the accession number does not change.

Field Name	Field Code	Example	Description and Notes
From database ²	FDB	su("structural engineering") AND fdb(inspec) su("structural engineering") AND fdb(10000135)	Use in multi-file searches to isolate records from a single file. FDB cannot be searched on its own; specify at least one search term then AND it with FDB.
Identifier (keyword)	IF	if("constrained differential evolution")	
Images		signal* AND ftany(yes)	A small number of images are present in records from 1897 to 1968. Records with images can be identified by adding <i>AND FTANY(YES)</i> to the query.
ISBN	ISBN	isbn(9783642135941)	
ISSN	ISSN	issn(0957-4174) issn(09574174)	Also searchable in the <i>Look Up Citation</i> tool.
Issue	ISS	iss(20)	Also searchable in the <i>Look Up Citation</i> tool.
Language	LA	la(french)	LA searches for language of original publication; all Inspec abstracts are in English.
Numeric indexing			Refer to the separate <i>Numeric Indexing</i> section, below.
Pagination	PG	pg(7057-69) pg(7057)	Page ranges can be searched, but we recommend that you should search only the start page. Also searchable in the <i>Look Up Citation</i> tool.
Patent information	PAT	pat(otis N/1 elevator and 1975)	Patent information is only available between the years 1906- 1976.
Inventor	INV	inv(Goodwin, e. c.)	
Patent application date	PAD	pad(1973-02-05)	
Patent assignee	AP	ap("lucas elec co. ltd.")	
Patent priority application number	APN	apn(2310718)	
Patent priority date	PRD	prd(19750525) prd(>19751231)	Date range searching is supported.
Patent publication date	PDA	pda(19760128)	Date range searching is supported.
Patent publication number	PN	pn(1422775)	
Patent publication country	PC	pc(gb) pc(us)	
Publication date	PD	pd(20151115) pd(20150701-20151231)	Date range searching is supported.
Publication year	YR	yr(2015) yr(2013-2015)	Date range searching is supported.
Publication title ¹	PUB	pub("expert systems with applications") pub(nature)	
Publisher location	PBLOC	pbloc(netherlands)	

Field Name	Field Code	Example	Description and Notes
Publisher name	PB	pb(elsevier) pb("wuhan university")	For dissertation-type records the publisher name field contains the university name.
Report number	RP	rp(iet-tv.44.9563)	
Subfile	FSU	fsv("electrical and electronic engineering") fsv("information technology for business") fsv("mechanical and production engineering") fsv("computing and control engineering") fsv("physics")	You can also select these from the list of subfiles on the Advanced Search page. A record may appear in more than one subfile.
Subject ¹	SU	su("mechanical engineering")	SU retrieves data from multiple fields including <i>Subject, Identifier (keyword), Classification (text only)</i>
Main subject	SUBT	subt("evolutionary computation")	SUBT searches terms from the <i>Subject</i> display field only. Terms selected from the Subject filter use the SUBT field code.
Substance	SUBST	subst("si-al-au int") subst("ce - el") subst("si - int" and "si - el") subst(fe and si) subst(gaas bin)	Available in some records from January 1987 onwards. Chemical indexing is structured to search both the substance(s) and/or role(s). Refer to " <i>Chemical Indexing Roles</i> " below. See also Chemical Indexing, CI.
Summary Language	SL	sl(english)	Language of abstract. All abstracts are in English.
URL	URL	url(http://www.dlib.org/dlib/december02/rauber/12rauber.html) av(http://www.dlib.org/dlib/december02/rauber/12rauber.html)	Also searchable using field code AV.
Updated	UD	ud(2013-12-12)	The date(s) the record was loaded as a result of an update provided by the supplier.
Volume	VO	vo(42)	Also searchable on the Look Up Citation page.

¹ A Lookup/Browse feature is available for this field in the Advanced Search dropdown or in Browse Fields.

² Click the "Field codes" hyperlink at the top right of the Advanced Search page. Click "Search syntax and field codes", then click on "FDB command" to get a list of database names and codes that can be searched with FDB.

Search tools

In addition to *Search Fields*, other tools available for searching are *Limit options*, *Browse Fields*, *“Narrow results by” Filters*, and *Look Up Citation*. Each is listed separately below. Some data can be searched using more than one tool.

Limit options

Limit options are quick and easy ways of searching certain common concepts. Limit check boxes are available for:

Abstract included

Short lists of choices are available for:

Document type, Language, Document treatment, Subfile

Date limiters are available in which you can select single dates or ranges for date of **publication** and **updated**.

Browse fields

You can browse the contents of certain fields by using Look up lists. These are particularly useful to validate spellings or the presence of specific data. Terms found in the course of browsing may be selected and automatically added to the Advanced Search form. Look up lists are available in the fields drop-down:

Author, Classifications, Major Classifications

and in the fields drop-down only for:

Authors, Publication title

Thesaurus

The Inspec Thesaurus is available by clicking on the “Thesaurus” hyperlink on the right-hand side of the Advanced and the Command Line search pages. Thesaurus terms may be searched within the thesaurus, then selected to be added automatically to the search form.

“Narrow Results By” filters

When results of a search are presented, the results display is accompanied by a list of “Narrow results by” options shown on the right-hand panel. Click on any of these options and you will see a ranked list showing the most frequently occurring terms in your results. Click on the term to apply it to (“narrow”) your search results. “Narrow results by” filters in Inspec include:

Author, Classification, Classification (IPC), Document type, Language, Publication date, Publication title, Source type, and Subject

Look up citation

If you need to trace a particular bibliographic reference, use the Look Up Citation feature. Find a link to this toward the top left of the Advanced Search page, or in the drop list under Advanced on any search form; click this and you will go to a form where you can enter any known details of the citation, including document title, author, journal name, volume, issue, page, publication date, ISSN.

International Patent Classification (IPC)

IPC classification codes may be applied to ALL record types – not just patent records. Searching with IPC codes is an ideal way to link the non-patent literature content of Inspec with Dialog's patent collection. Finding research and prior art relating to filed patents is simplified by the presence of IPC codes in Inspec records. Note that IPC codes are mapped to Inspec's own classification coding system; since IPC coding is very precise, there may not always be a one-to-one match, so you should use broader IPC codes to ensure accurate retrieval.

The following is a link to WIPO's own IPC classification look-up. It is arranged hierarchically. Use this tool to find appropriate codes for searching: <https://www.wipo.int/classifications/ipc/ipcpub>).

Chemical Indexing Roles

Chemical indexing is displayed in the Substance field and is searchable with the SUBST and CI field codes. The following roles are also searchable:

ADS	Adsorbate or any sorbate (i.e., any species being (ad)sorbed onto a substrate)
BIN	Binary system (2 elements, whether compound or alloy, and regardless of the relative proportions of the two)
DOP	Dopant
EL	Element
INT	Interface system
SS	System with three or more components
SUR	Surface or substrate

Roles can be searched on their own – e.g. SUBST(INT), or in combination with an element or molecule – e.g. SUBST("H2SO4 – SS")

Numeric indexing

Numeric data, such as temperature, pressure, frequency, etc., are indexed for many records added to Inspec since February 1987.

Values are presented in floating point format, e.g. 1.8E+04 for 18000 and 9.5E-01 for 0.95.

For search purposes, do NOT use the '+' sign, and leading zeroes are optional – ie. to retrieve the specific displayed value of '1.8E+04' search as '1.8E4' or '18000'.

However, you MUST use the '-' symbol to retrieve decimal values – ie. to retrieve the specific displayed value of '9.5E-01' search as '0.95' or '9.5E-1'.

When searching **ranges**, use a hyphen (dash) between the values searched WITHOUT a space either side of the hyphen:

NIDI(5-50) or NIDI(5E0-5E1) to retrieve any records with a Distance numeric value between **5m - 50m**.

NICD(0.0000001-0.0001) or NICD(1.0E-7-1.0E-4) to retrieve any records with a Conductance numeric value between **0.0000001Siemens - 0.0001Siemens**.

Refer to the table below for examples of numeric searching.

Field and SI unit	Field Code	Example
Numeric indexing type	nitype	nitype(altitude), nitype("apparent power"), nitype("galactic distance"), nitype("electron volt energy"), nitype(mass not "stellar mass"), nitype(resistivity), etc.
Age (yr; Year)	niag	niag(2-5)
Altitude (m; Meter)	nial	nial(2E4-9E5)
Apparent power (VA; Volt-amp)	niap	niap(3E6)
Bandwidth (Hz; Hertz)	nibw	nibw(4.0E8)
Bit rate (Bit/s; Bits per Second)	nibi	nibi(64000)
Byte rate (Byte/s; Bytes per Second)	niby	niby(10E6)
Capacitance (F; Farad)	nica	nica(3.0E-11)
Computer execution rate (IPS; Instructions/Second)	nice	nice(1E7)
Computer speed (FLOPS)	nicm	nicm(1.5E10)
Conductance (S; Siemens)	nicd	nicd(1.0E-7-1.0E-4)
Current (A; Ampere)	nicu	nicu(5.6E-3)
Depth (m; Meter)	nidp	nidp(2E4-9E5)
Distance (m; Meter)	nidi	nidi(0.002), nidi(2E-3)
Efficiency (Percent)	nief	nief(1.0E1), nief(10)
Electrical conductivity (S/m; Siemens per Meter)	niel	niel(1.0E1)
Electron volt energy (eV; Electron Volt)	niev	niev(1.07-1.82)
Energy (J; Joule)	nien	nien(0.5)
Frequency (Hz; Hertz)	nifr	nifr(5.2E9)
Gain (dB; Decibel)	niga	niga(2.03E1)
Galactic distance (pc; Parsec)	nigd	nigd(1.2E5)
Geocentric distance (m; Meter)	nige	nige(3E7)
Heliocentric distance (AU; Astronomical Unit)	nihd	nihd(5E1)
Loss (dB; Decibel)	nils	nils(1.5E1)
Magnetic flux density (T; Tesla)	nimd	nimd(1E-2)
Mass (kg; Kilogram)	nima	nima(2.4E-3-2.42E-1)
Memory size (Byte)	nims	nims(>=3E7)
Noise figure (dB; Decibel)	ninf	ninf(5-7)
Picture size (pixel; Picture Element)	nipx	nipx(1.28E2)
Power (W; Watt)	nipo	nipo(5.0E2), nipo(500)
Pressure (Pa; Pascal)	nipr	nipr(1.3E-3), nipr(0.0013)
Printer speed (cps; Characters per Second)	nips	nips(2.7E2)
Radiation absorbed dose (Gy; Gray)	nira	nira(2)
Radiation dose equivalent (Sv; Sievert)	nird	nird(1.0E-3)
Radiation exposure (C/kg; Coulomb per Kilogram)	nirx	nirx(<=0.1)
Radioactivity (Bq; Becquerel)	niry	niry(4.0E4)
Reactive power (VAR; Volt-Amp Reactive)	nirp	nirp(<=3.0E8)
Resistance (ohm)	nire	nire(7E-5)
Resistivity, electrical (ohmm; Ohm meter)	nier	nier(5.0E-3), nier(0.005)
Size (m; Meter)	nisi	nisi(1.0E-6)
Stellar mass, Msol; Solar Mass)	nism	nism(1.1E1), nism(11)
Storage capacity (Bit)	nistr	nistr(1.0E6)
Temperature (K; Kelvin)	nite	nite(3.26E2)
Time (s; Second)	nitm	nitm(1.35E-1)

Field and SI unit	Field Code	Example
Velocity (m/s; Meters per Second)	nive	nive(1.0E4)
Voltage (V; Volt)	nivo	nivo(>=10000)
Wavelength (m; Meter)	niwa	niwa(1.1E-6)
Word length (Bit)	niwl	niwl(32-128)

Document formats

Document Format	Fields	Online	Export / Download
Brief view	Title and Publication date.	✓	
Detailed view	Same as Brief view plus a 3-line KWIC window.	✓	
KWIC (Keyword in Context)	Detailed view plus all occurrences of your search terms, highlighted within the fields where the terms occur.	✓	✓
Preview	Title, Author, Publication title, Publisher, Volume, Issue, Pagination, Publication date, Abstract.	✓	
Brief citation	Complete record minus Abstract and Indexing	✓	✓
Citation / Abstract	Complete record	✓ ¹	✓
Custom	Choose the fields you want.		✓ ²

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² Custom export/download format is available in the following mediums only: HTML, PDF, RefWorks, RTF, Text only, XLS.

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