

IPOL: a new journal for fully reproducible research; analysis of four years development

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Reproducible research in sciences:

- *Theoretical scientists* share demonstrations:

$$C(nT) = 2n + 1 + C(1^2) + C(2^2) + \dots + C((n-1)^2) + C(n^2)$$

$$= 2n + 1 + 2n + 1 + 2n + 1 + \dots + 2n + 1 + C(n^2) \dots etc$$

$$C(nT) = 2n + 2n + 2n + 2n + \dots + 2n + C(n^2) \dots etc$$

The recurrence equation then leads us to the summation equation:

$$2n(1 + 2 + 3 + \dots + n) + C(n^2)$$

Since we know the converging value of the summation series states:

$$\sum_{i=1}^n i = \frac{n(n+1)}{2} \quad \text{if } |x| < 1$$

This in turn leads us to the closed form formula:

$$2n \left(\frac{n(n+1)}{2} \right) + C(n^2)$$

Proof by induction:

Inductive hypothesis: $C(nT) = \frac{1}{2}n^3 + \frac{1}{2}n^2 \quad \forall n \in \mathbb{N}$

Inductive Step:

$$2nK + C(n^2) = \frac{1}{2}n^3 + \frac{1}{2}n^2$$

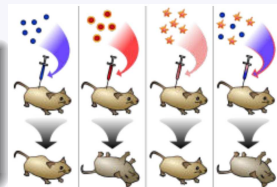
$$2nK - \frac{1}{2}n^3 - \frac{1}{2}n^2 = \frac{1}{2}K^3 + \frac{1}{2}K^2$$

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1. The IPOL Journal: context of reproducible research (1)

Reproducible research in sciences:

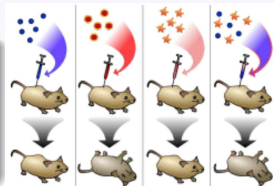
- *Theoretical scientists* share demonstrations;
- *Experimental scientist* share procedures;



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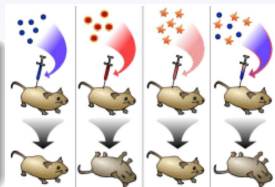
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- *Computational scientists... ?*



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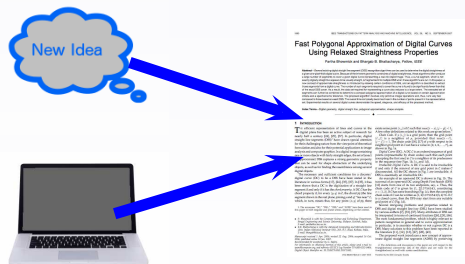
Computer Science:

- Description of methods/algorithms;
- description often limited (constraints on page limits);
- parameters not given or not well described;
- steps of pre/post processing missing.

1. The IPOL Journal: context of reproducible research (2)

Research in Computer Science:

- 1 New idea;
- 2 demonstration, implementation;
- 3 article publication.



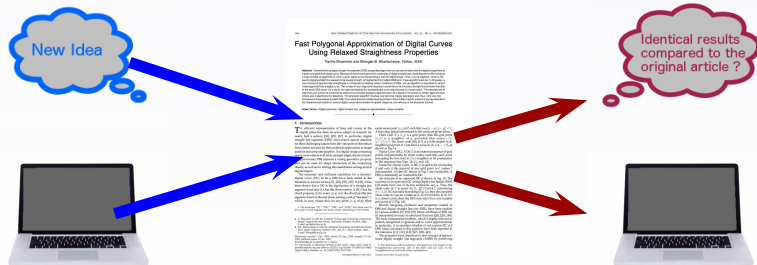
1. The IPOL Journal: context of reproducible research (2)

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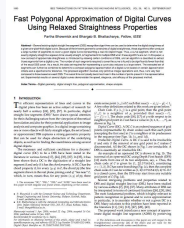
Reusable Research:

- 1 Article which seems interesting;
- 2 re-implement the algorithm;
- 3 conformity of the results with the original.



Frequent difficulties in computer science (image processing):

- Source code often not available (or not reviewed);
- quality/stability of the results not easy to analyze;
- testing with different input data not possible.



1. The IPOL Journal: context of reproducible research (3)

Frequent difficulties in computer science (image processing):

- Source code often not available (or not reviewed);
- quality/stability of the results not easy to analyze;
- testing with different input data not possible.

Consequences:

- Comparisons and experiments difficult;
- potential time loss for the reader;
- limits the diffusion of research.



1. The IPOL Journal: context of reproducible research (4)

Providing source code/data

- ⊕ A real added value for the publication;
- ⊕ increases the impact/comparisons;
- ⊖ software is not really acknowledged;
- ⊖ important effort (documentation, tests, user maintenance).

```
#include <iostream>
#include "GGIst/Share/Common.h"
#include "GGIst/IO/readers/rdHeader.h"
#include "GGIst/IO/Display3D.h"

#include "GGIst/Interface/Display3DModifier.h"
#include "GGIst/Image/ImageSelector.h"
#include "GGIst/Image/ImageSetUtils/SetFromImage.h"
#include "GGIst/Helpers/Helpers.h"
#include "ConfigExamples.h"

using namespace std;
using namespace GGIst;
using namespace Z3i;

int main(int /argc/, char** /argv/)
{
    std::string InputFilename = examplesPath + "samples/X1.100.vol";
    // [ExampleDisplay3DTestFF]
    Display3DSpace, KSpace viewer;
    Image ImageSelector = Z3i::Image, Image::Type Image;
    Image Image = VolReader::Image::ImportVol(InputFilename);
    Z3i::ImageSet set3d(Image, Image::SetFromImage);
    SetFromImage(Z3i::ImageSet); ImageSet ImageSet(set3d, Image, 0, 255);

    viewer << set3d;
    viewer << "ImageSetTestFF.off";
    // [ExampleDisplay3DTestFF]
    return 0;
}
```

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```
#include <iostream>
#include "GData/Share/Camera.h"
#include "GData/IO/readers/rtReader.h"
#include "GData/IO/Display3D.h"

#include "GData/IO/Draw/3D/Display3DModifier.h"
#include "GData/IO/Draw/3D/ImageSelector.h"
#include "GData/IO/Draw/3D/ImageSetUtils/SetFromImage.h"
#include "GData/IO/Draw/3D/Objects.h"
#include "Config/Examples.h"

using namespace std;
using namespace GData;
using namespace Z3;

int main(int /argc/, char** /argv/)
{
    std::string inputImage = examples[1].img_voi;
    // [ExampleDisplay3DTest]
    Display3DSpace, KSpace viewer;
    CreateImageSelector = Z3::Image, int::Type Image;
    Image image = VolReader::Image::ImportVol(inputImage);
    Z3::ImageSet set(image, image.GetSize());
    SetFromImage(Z3::ImageSet::ImageImage(set3d, image, 0, 255));

    viewer << set3d;
    viewer << "OpenMeshToOFF.off";
    // [ExampleDisplay3DTest]
    return 0;
}
```

Software Diffusion

- Specialized journals in software:
Source Code for Biology and Medicine, Journal of Open Research Software, Computing in Science and Engineering, ...
- Diffusion platform:
RunMyCode / Run&Share, Figshare, DataDryad, Harvard Dataverse, Ubiquity Metajournals, Zenodo (with doi) ...

⇒ no validation, no scientific review (reliability and durability problem).

1. The IPOL Journal: origin and motivation

Origin:

- Journal started in October 2009;
- under the initiative of Nicolas Limare, Jean-Michel Morel and the Image Processing team at the CMLA lab (ENS-Cachan);
- first article published in 2010.

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Motivation [Limare & Morel 2009]:

- Reproducible research;
- new way to publish research results;
- allows everybody to test the algorithms;
⇒ with their own images
- independent of the platform (the demos execute on the server side and the results are shown to the user using a web interface).

1. IPOL Journal: principle and current form (1)

Characteristics:







- Research journal in **image** processing;
- each article contains a description of **one algorithm** and its **source code**;
- association of each **article** with its **online demonstration**, with **archived** experiments;
- the peer-review process includes the **article**, **demo**, and **source code**;
- *Open Science* journal and **Reproducible Research**.




IPOL Journal · Image Processing On Line

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IPOL is a research journal of image processing and image analysis which emphasizes the role of mathematics as a source for algorithm design and the reproducibility of the research. Each article contains a text on an algorithm and its source code, with an online demonstration facility and an archive of experiments. Text and source code are peer-reviewed and the demonstration is controlled. IPOL is an Open Science and Reproducible Research journal.

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1. IPOL Journal: principle and current form (2)

Philisophy of the journal:

- Follows the guideline on reproducible research topics;
- reproducible research standard [Stodden 09a] [Stodden 09b];
- answer to credibility crisis in scientific computation (as pointed out by Donoho [Donoho *et al.* 09]).

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Philisophy of the journal:

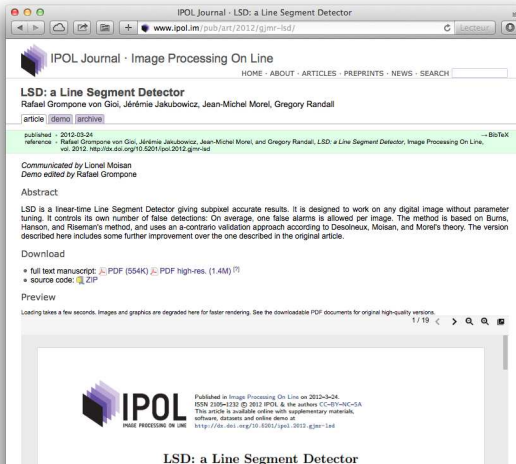
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What IPOL is not:

- IPOL publishes **algorithms** along with **their implementation**, but not compiled software;
- IPOL is not a software library (each code has minimal dependencies);
- IPOL is not a software or code diffusion platform.

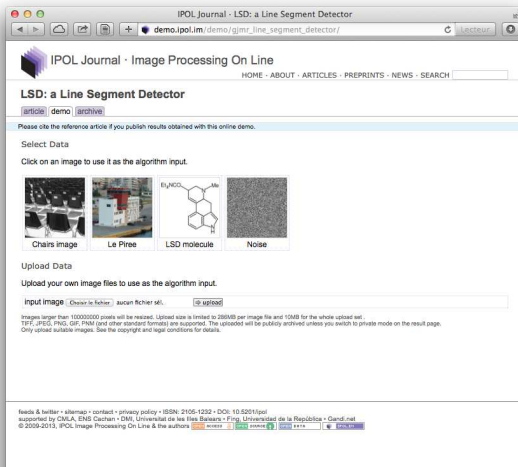
1. IPOL Journal: principle and current form (3)

- Current form: “classic” (with online PDF).



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- Associated demos.



1. IPOL Journal: principle and current form (3)

- Current form: “classic” (with online PDF).
- Associated demos.
- Archive containing experiments with data uploaded by users.

IPOL Journal - LSD: a Line Segment Detector

demo.ipol.im/demo/gjmr_line_segment_detector/archive/

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LSD: a Line Segment Detector

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Please cite the reference article if you publish results obtained with this online demo.

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pages: << >> >>> 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565

key	F125985328459207421C87B0C30878639	images	
date	2013/11/12 10:06		
LSD	Version 1.8 of November 11, 2011, compiled		
version	Jul 11 2013 16:48:31		
run time	5.57026418397		
(s)			
files	output.tst output.apis output.svg		
key	403F1B187CBA59208BA0C2C0B64F86	images	
date	2013/11/12 10:08		
LSD	Version 1.8 of November 11, 2011, compiled		
version	Jul 11 2013 16:48:31		
run time	0.786833047887		
(s)			
files	output.tst output.apis output.svg		
key	41F8B0F9CE7D086E8DC8F5D89C55AF5	images	
date	2013/11/12 10:13		
LSD	Version 1.8 of November 11, 2011, compiled		
version	Jul 11 2013 16:48:31		
run time	0.218708992004		
(s)			

1. IPOL Journal: editorial structure

Same aspects as a classical journal:

- Editorial project, editorial committee;
- articles, authors, editors;
- reviewing process and validation;
- ISSN, DOI;
- special issues;
- currently indexed by:
Scirus, Google Scholar, DBLP, DOAJ, SHERPA/RoMEO, Héloïse, WorldCat, CrossRef, Ulrich, Index Copernicus, PBN, JGate, VisionBib, CVonline, JournalSeek, and NewJour.

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Software point of view:

- Each article should propose an implementation;
- reviewing step, verification, validation, and publication;
- reviewer: **check the correspondence between the algorithm description in the article and code** (+ code readability and code documentation).

2. Scientific & technical achievements to establish a state of the art (1)

Image Denoising

- Papers on image denoising cover most of the state of the art in image denoising.
⇒ analyze and finalize the often incomplete algorithms.
- Online implementation allows the first objective comparison.
- **complete state of the art of denoising**

⇒ See the noise Clinic [\[Lebrun *et al.* 15\]](#)

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Stereovision

The stereovision category at IPOL contains **five fundamental algorithms**:

- Quasi-Euclidean Epipolar Rectification [\[Monasse 11\]](#).
- Kolmogorov & Zabih's graph cuts stereo matching algorithm [\[Kolmogorov et al. 14\]](#).
- Stereo disparity through cost aggregation with guided filter [\[Tan & Monasse 14\]](#).
- Integral images for block matching [\[Facciolo et al. 14\]](#).
- Bilaterally weighted patches for disparity map computation [\[Fernandez & Monasse 15\]](#).

⇒ Others in preparation.

2. Scientific & technical achievements to establish a state of the art (2)

Stereovision

- First workshop demo delivering a 3D digital elevation model of the ground from satellite images.
- available here: http://dev.ipol.im/~carlo/ipol_demo/workshop_s2p

3. Technical Issues Overcome Through the Development of IPOL

First problem: reference programming languages

The chosen languages must:

- have a **stable API**;
- be **used intensively** by reasearchers and the industry;
- have stable **standard libraries**.

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Accepted languages and libraries

- First accepted languages: **ANSI C/C++**;
- **currently accepted libraries**: `libtiff`, `libjpeg`, `libpng`, `zlib`, `FFTW`, `GSL`, `Eigen`, `cblas`, and `clapack`;
- currently accepted **MATLAB toolboxes**: Image Processing, Optimization, Wavelet;
- new accepted frameworks: **MATLAB**, **Python (with NumPy and SciPy)**;
- other languages might be considered and accepted.

Second problem: design an online demo system

A **demo system** was created for this purpose, from scratch. It has to **manage the execution** of each online experiment:

- The **parameters and result pages** are different in each demo;
- the **test images** are different in each demo;
- users must be able to **upload their own images**;
- it has to be **fast** enough to allow online execution → **Multiple CPU** system;
- it has to **archive** user experiments (input data, input parameters, and results).

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Problems detected in the current system

The current system is **usable** and **functional**, but we detected **several problems**:

- Creating a new demo implies **coding** in Python and **designing HTML templates**;
- **non-scalable, too complex internal structure**, and with **lack of modularization**.

⇒ **Now moving towards a modular system with automatic demo generation.**

Problems in the current demo system

- Most of the **problems** related to the **architecture** of the system;
- system designed as an object-oriented **monolithic** kernel;
- **too complex**, with **tightly interface-coupled** components;
- **non-scalable**;
- **not easy to distribute** the system over different machines.

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Improvements

We're currently working on **improving the system**

- **Modular architecture:**
 - Specialized standalone modules;
 - the monolithic kernel becomes a simple controller;
 - the core controller and the modules communicate via webservice.
- **Automatic demo generation:**
 - Each demo is specified using a simple textual description (name, type, and default value of the parameters and format of result page);
 - no need to code or design any page to build a new demo.

Quality of articles and a “natural selection”

Most **failed IPOL projects** aborted when:

- the described **algorithm** was **incomplete**;
- **did not give all the results** described in the paper;
- **run time** not reasonable;
- worked **only on a certain type of data**.

Progress towards the **establishment of a full state of the art** in each of the main sections of the journal

Identify algorithms representing a very substantial portion of the state of the art:

- Most **efficient algorithms** should be published;
- proposed theories and methods, **even though they are not** (or no longer) considered **the best**.

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Some sections currently in IPOL

- Color and Contrast (10 articles)
- Denoising (15 articles)
- Demosaicking (6 articles)
- Interpolation (4 articles)
- Optical Flow (6 articles)
- Vision Through Turbulence (3 articles)
- ...

Goal: cover must of their respective state of the art (performance and descriptions of main mathematical techniques)

Others sections

- 3D
- Blur
- Computational Photography
- Geometry
- Infrared
- Learning and Detection
- Inpainting
- Image Comparison
- PDE
- Stereovision
- Texture
- ...

→ **However, still incomplete!**

Example of advantages of a reproducible algorithms with Stereovision: **Middlebury stereo evaluation**

- One **method** [Fernandez & Monasse 15] was **implemented** from an algorithm on adaptive neighborhoods [Yoon & Kweon 06];
- the obtained **results were different!**
- it was discovered that a **post-processing** must be applied to the main algorithm;
- there is **no mention of a post-processing in the original article** [Yoon & Kweon 06]!

Criticism to IPOL

- **Excessive effort** (rigor, run on any data, code description);
- **excessive length** of the **peer review report** (including code review: slow and demanding);
- **large number of objects** to be published (article, source code, demo);
- no official **impact factor**;
- **frustrating to work on algorithms** designed by **others**;
- **restricted** number of **authorized libraries or toolboxes** (as `libjpeg`, `libtiff`, `FFTW`, `MATLAB Image Processing toolbox`,...)

Authors and publishers praised IPOL for:

- **Immediate impact** of their publication;
- **impact** due to the very **existence of the demo**;
- gain tangible industrial and academic **credibility**;
- facilitate obtaining **research funding** (ERC, ONR, ANR, DGA, CNES, FUI, ...)

Conclusions (I)

- **Reproducible Research** redefines the **output of the research**: not only the article, but also the **source** code and the **data**.
- **IPOL** is a **complete** and **fully functional Reproducible Research journal**: **articles, demos, data**. **Everything is free or open source**.
- For the **authors** it takes **more effort** to write Reproducible Research articles, but:
 - ⇒ **benefit is immediate** (**credibility** and **number of citations**);
 - ⇒ for both the IPOL article and the one published in a different journal with a demo available in IPOL).
- It is important to **adapt the journal to the community** needs and usages:
 - ⇒ **accept** commonly used languages, libraries, and frameworks.

Conclusions (II)

Pseudo-code is the main production of IPOL over the source code itself:

- The pseudo-code **describes** the **significant parts** of the **algorithm**;
- it **does not contain all the details** needed to encode it using an actual programming language;
- the pseudo-code is aimed to be **readable**, and **reusable**;
⇒ in general, it is between **one and two orders of magnitude shorter** than the actual source code.
- the pseudo-code is **unambiguous** to the mathematician reader.

What is Next? (I)

Facts:

- More than 5000 articles/year on Computer Vision and Image processing describing algorithms;
- however, about 200 of these articles would be enough to cover the CV and IP state of the art. Less than 400 if exhaustive.

IPOL is producing 40 articles/year → It can exhaust the state of the art (old and new) in about 7 years.

What is Next? (II)

Moving towards a new way to do research

- What is next, then? → Focus on incremental research.
- Antecedents: analysis of the genome.
- Cycle:
 - 1 review established and published algorithms;
 - 2 combine them;
 - 3 improve them to achieve new and better results and applications.

In definitive, a new methodology to do research in CV and IP

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