# ImJoy: A computational platform for the deep learning era

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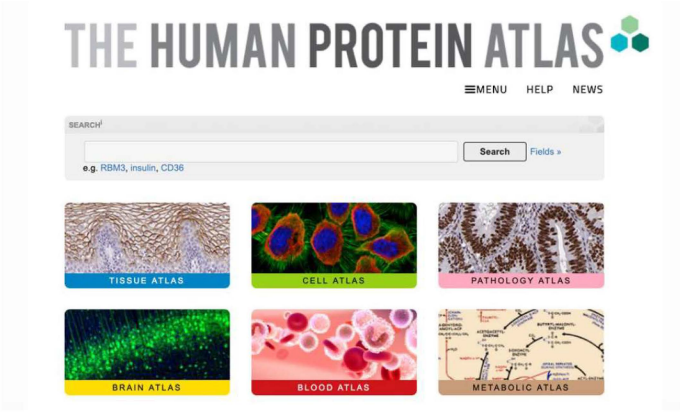
# Overview

- Human Protein Atlas and HPA image classification competition
- ANNA-PALM: Deep learning for super-resolution microscopy
- ImJoy: A computational platform for the deep learning era

# The Human Protein Atlas

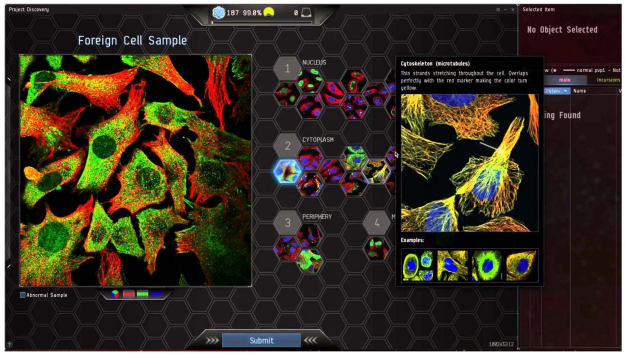



- Mapping the human proteome using in-house generated proteome-wide collection of antibodies.
- Using large-scale immunostaining and high-resolution microscopy
- Freely available database: [www.proteinatlas.org](http://www.proteinatlas.org)

## HPA Cell Atlas

Prof. Lundberg

"Foreign Cell Sample" Classification





- >322,000 players on EVE online
- 32,000,000 classifications (70 working years)

*Uhlen et al, A tissue based map of the human proteome, Science, 2015*
*Thul et al, A subcellular map of the human proteome, Science, 2017*

*Sullivan et al, D, Nature Biotechnol. 2018*

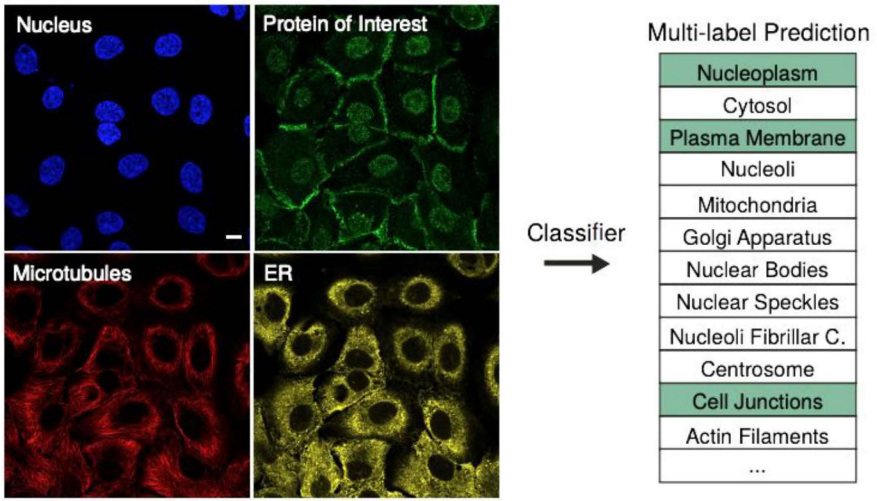
Featured Prediction Competition

# Human Protein Atlas Image Classification

Classify subcellular protein patterns in human cells

$37,000
Prize Money

Human Protein Atlas · 2,172 teams · 4 months ago

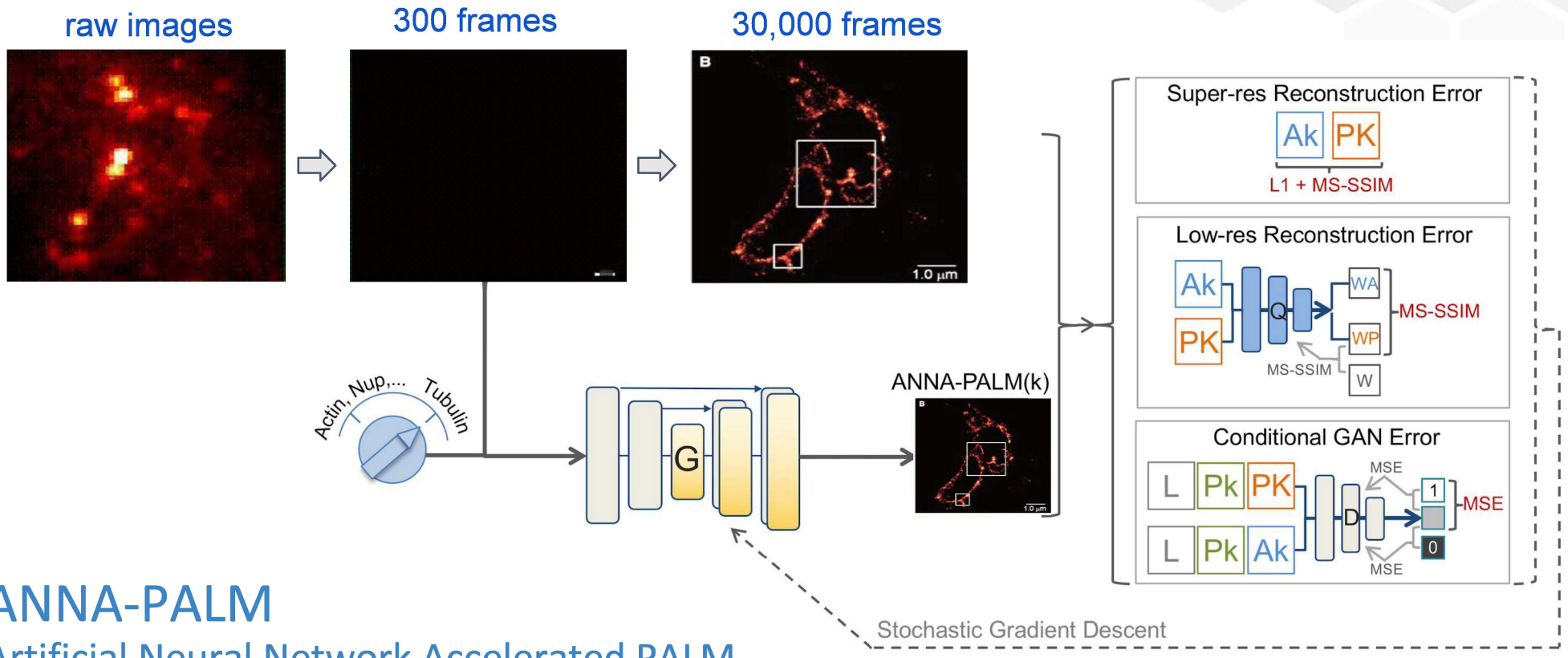



- >120,000 annotated images
- $37,000 prize money
- 3 months
- >2,000 teams
- >55,000 submissions
- Top model: Densnet 121 + lovaza loss etc.
- 20% higher score than previous record

**Deep learning + large image dataset + crowdsourcing!** **Ouyang et. al, Nat Methods, 2019**

# Deep learning accelerated Super-resolution microscopy

# Artificial Neural Network Accelerated PALM/STORM

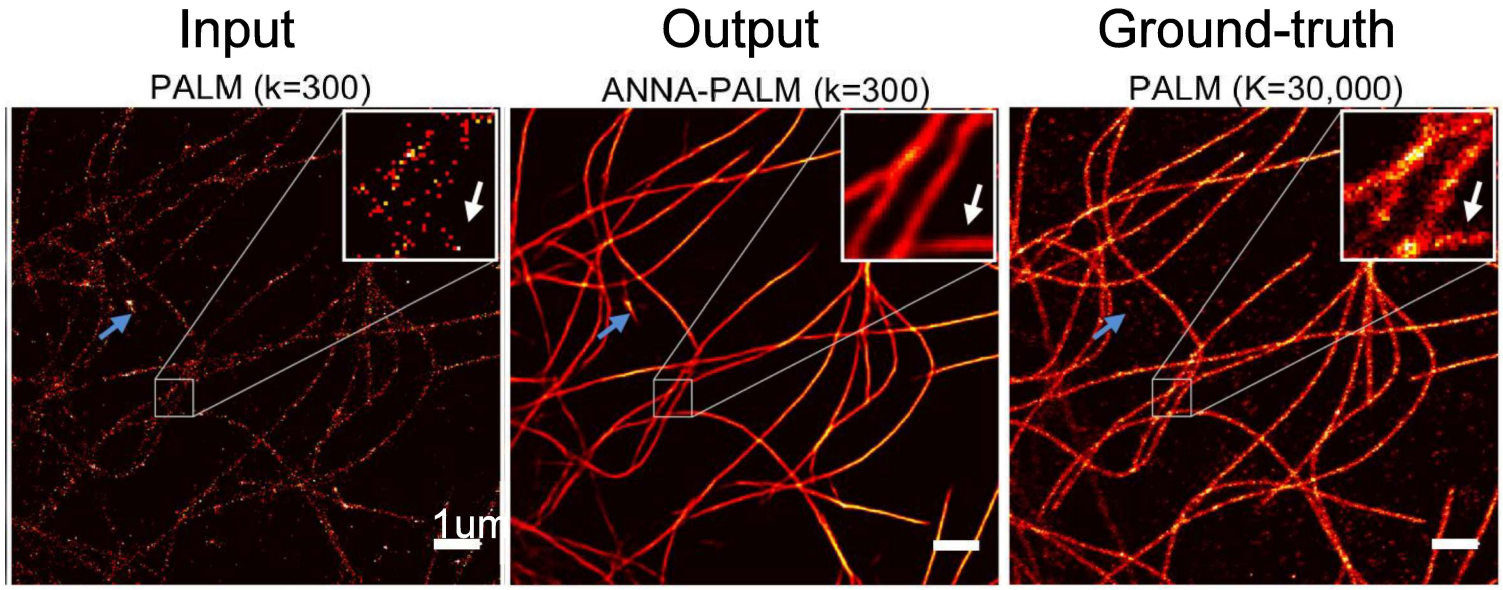



## ANNA-PALM

### Artificial Neural Network Accelerated PALM

Betzig et al. Science 2006  Ouyang et. al, Nat Biotechnol, 2018

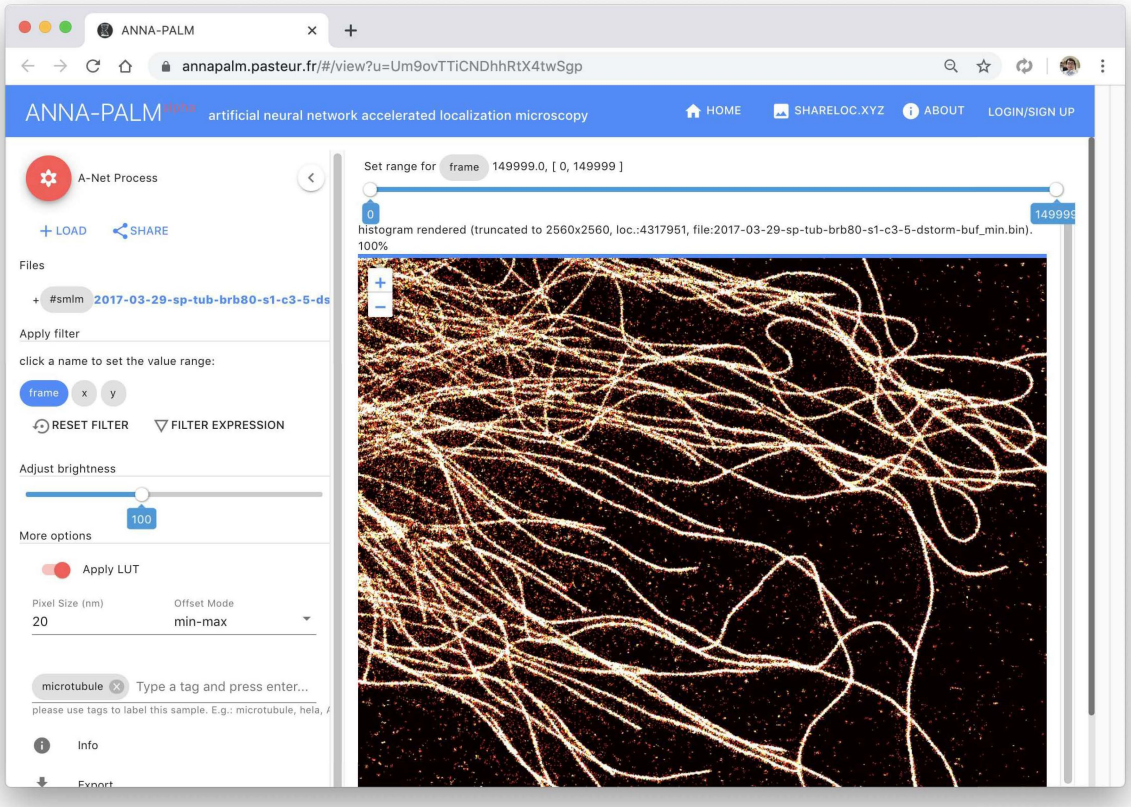
# ANNA-PALM: 100x faster SR imaging





Ouyang et. al, Nat Biotechnol, 2018

# Web Application for ANNA-PALM




- No installation required

- Not Scalable
- Data transmission
- **Maintenance required!**

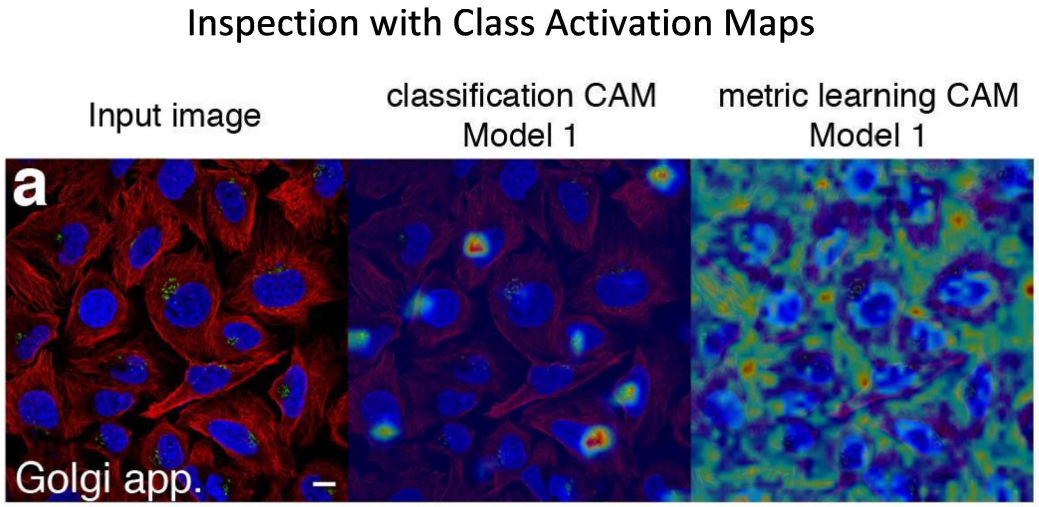
- Cost
- Privacy, GDPR

**Useful, but requires improvements!**

# ImJoy: An open-source computational platform for the deep learning era

# Software for the deep learning ara

- Large dataset, remote storage, online database (IDR, HPA)
- Computationally hungry (GPU/TPU/NPU...)
- Interactively inspect, annotate data and train model (human-in-the-loop)



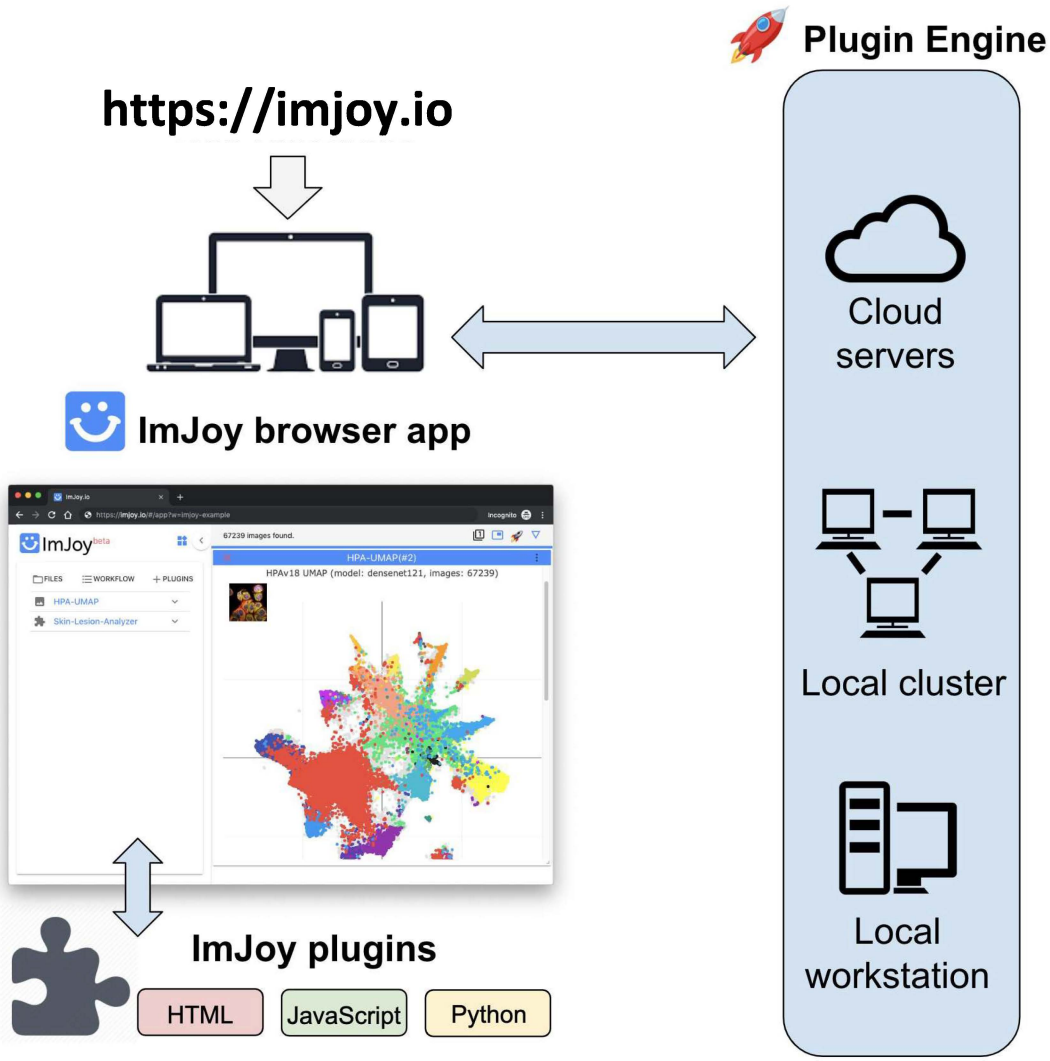

Ouyang et. al, Nat Methods, 2019

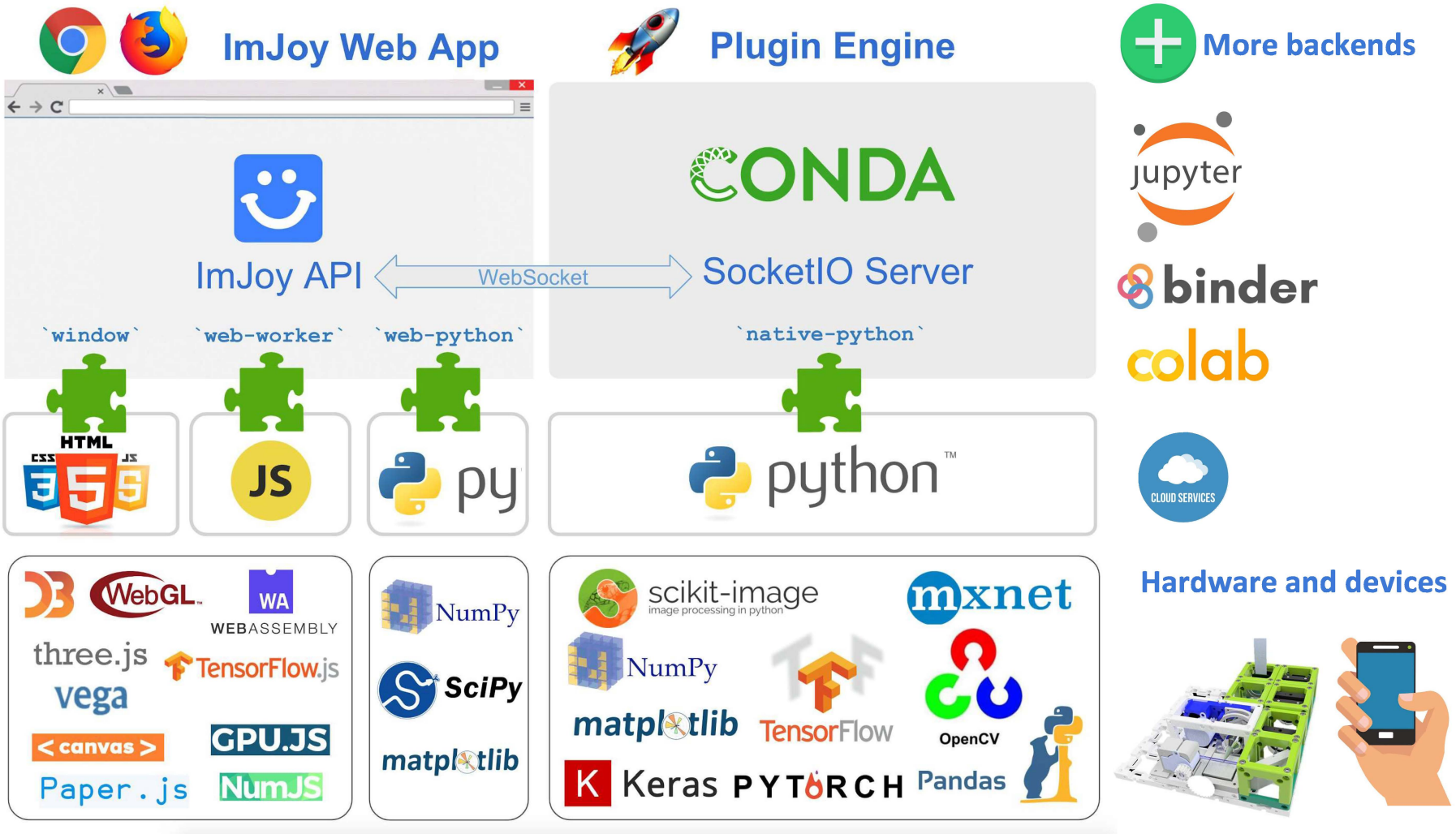
# Opportunities

- **Deep learning libraries**: Keras/Tensorflow, Pytorch
- **Mobile** is the biggest platform
  - > 5 billion mobile devices
- **Cloud** computing and remote data access
  - cloud services: storage, GPU, database, serverless, AutoML, Kubernetes
  - Free computation: Google Colab, **MyBinder.org**
  - **Remote Storage: S3, N5, Zarr, Dask Array**
- **Web** standards
  - HTML5 standards, JS libraries, nodejs/npm
  - UI standards (e.g. material design)
  - Progressive Web App, offline support
  - **WebAssembly** (porting C/C++, C#, Rust, Python)
  - **WebGPU** (deep learning in the browser)

# ImJoy

- Hybrid computing modes
  (browser + local + cloud)
- Progressive Web App ⇒ Offline support, mobile support
- Web Assembly/Web GPU ⇒ browser based computing, security






Minimal but powerful!

ImJoy

# Key ideas

- Each plugin import and export a set of service functions
- Transparent, symmetrical Remote Procedure Calls (RPC) ⇒ across plugins/programming language/host (also see **RPyC** in Python)
- Asynchronous execution ⇒ dynamic workflow composition

(Inspired by Crossbar.io, Jailed.js, Tensorflow, Pytorch)

ImJoy

# workflow composition: RPC + Async

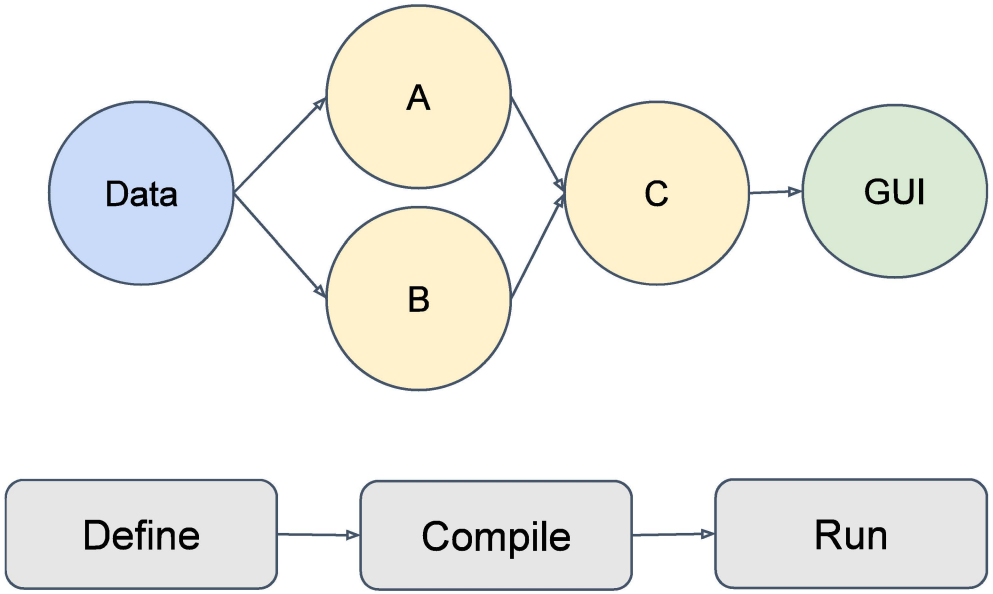
```python
import asyncio
from imjoy import api

class ImJoyPlugin():
    async def setup(self):
        self.pluginA = await api.getPlugin('pasteur.fr/pluginA')
        self.pluginB = await api.getPlugin('kth.se/pluginB')
        self.pluginC = await api.getPlugin('pluginC')
```

```python
    async def concurrent_workflow(self, x):
        promiseA = self.pluginA.process(x)
        promiseB = self.pluginB.process(x)
        resultA, resultB = await asyncio.gather(promiseA, promiseB)
        result = await self.pluginC.process(resultA, resultB)
        return result
```

# ImJoy static vs dynamic workflow

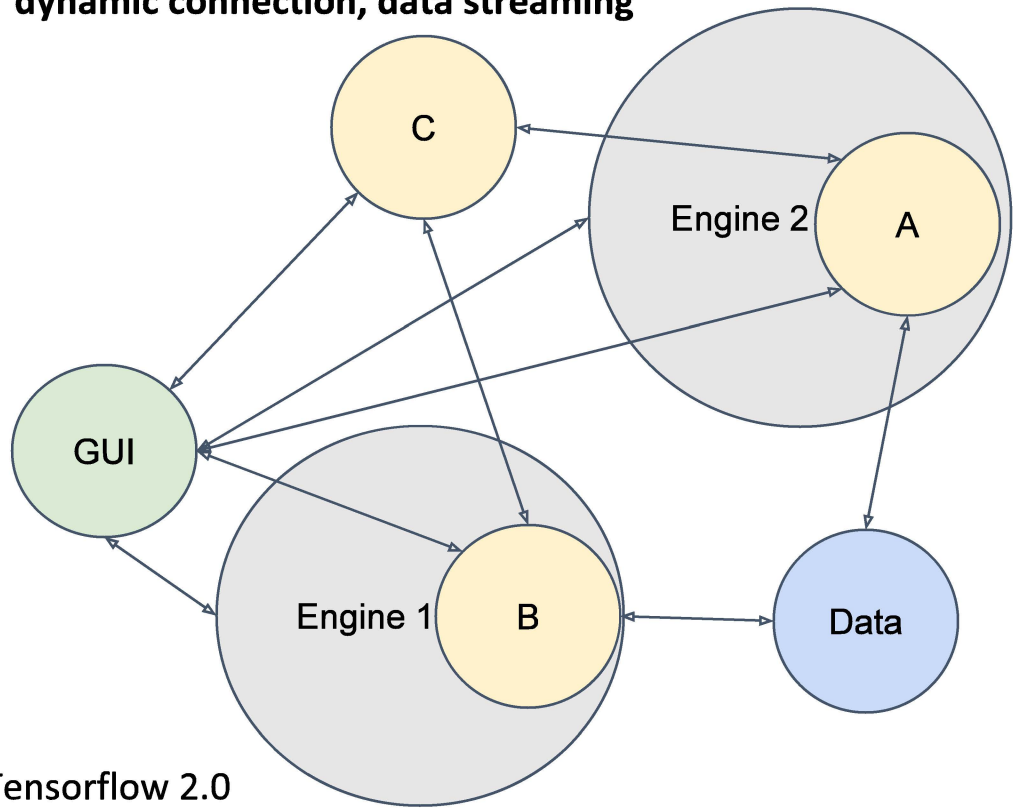
**Fixed node/connection, file based io**
**single workflow engine**




Tensorflow 1.x

Hard to debug!

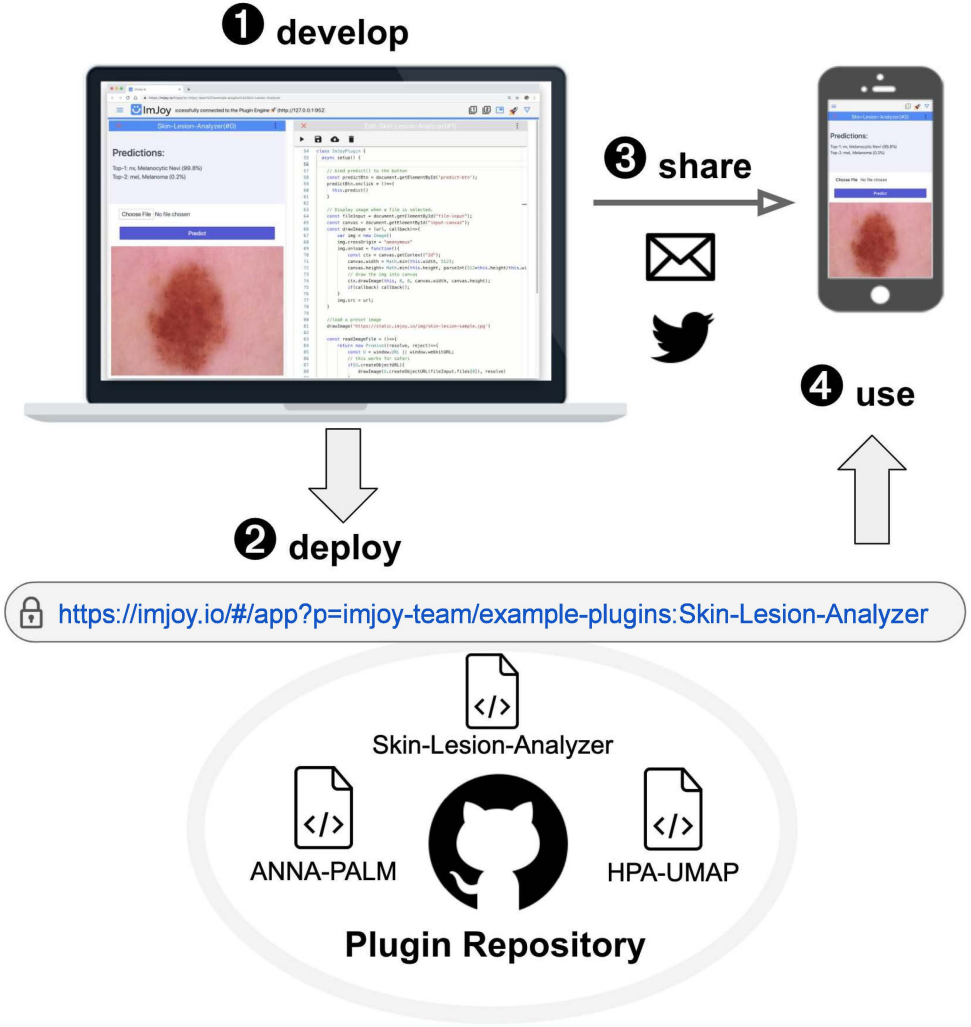
**Self-organizing, dynamic node**
**dynamic connection, data streaming**




Tensorflow 2.0

Pytorch

ImJoy




Skin Lesion Analyzer

Noise2self 🚀

Static web app: high scalability & availability, ~ zero cost

# ImJoy

- Plugin repository

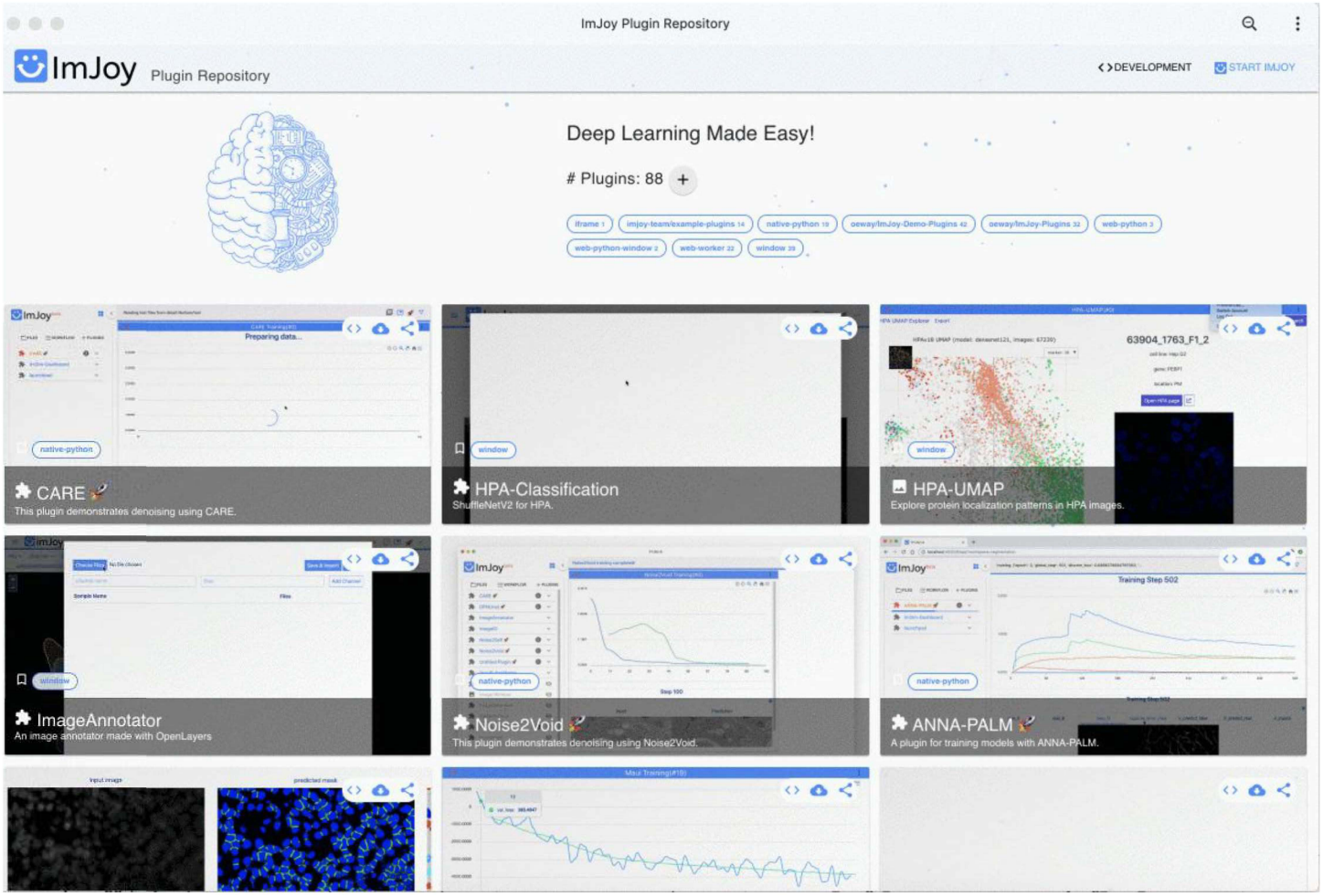
demo plugins

[Image Annotator](annotation)
[HPA-UMAP](visualization)
[Skin-Lesion-Analyzer](classification)
[HPA-Classification](classification)

🚀 [Interactive Plot](basic example)
🚀 [DeepBindScan](Genomics)

🚀 [Noise2Self](Denoising)
🚀 [ANNA-PALM](super-resolution)
🚀 [CARE](3D image denoising)
🚀 [DPNUnet](Segmentation)
🚀 [ImageJ Demo](PyImageJ)

(🚀: requires plugin engine)

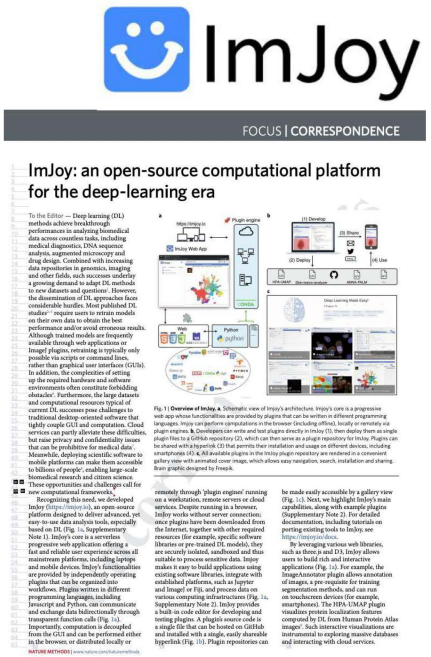


# Conclusion

- HPA competition: large image database + deep learning
- ANNA-PALM: Deep learning accelerated SR imaging
- ImJoy makes it easier to deploy deep learning models
  - Progressive Web App, Web Assembly, HTML5
  - Extendable Plugin Engines
  - Transparent Remote Procedure Calls
  - Async workflow composition
  - Static, scalable, high availability, almost zero cost

ImJoy is now published in Nature Methods: https://rdcu.be/bYbGO
(Deep Learning focused Issue)

**Work in progress: data viewers, plugin engine, useful plugins!**



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Thank you!

# Useful links for ImJoy

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Source code and documentations

- documentation, API functions
- main repo, plugin-engine

Example Plugins

- official plugin repository, example plugins

Getting Help

- Image.sc Forum
- ImJoy Slack

Bug Report

- ImJoy Issues

Preprint on Nature Methods: https://rdcu.be/bYbGO