Jug: Executing Parallel Tasks in Python

Luis Pedro Coelh

EMBL

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- Parallel Python code
- Memoization
Example: Evaluating Segmentation Methods
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Problem Statement

1. You have images to segment
2. Many algorithms available
3. Which one is best?
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Solution

1. Manually segment a few images (reference)
2. Run algorithms on these images
3. Compare with reference
Reference Segmentations
If your software is really that good, you don’t fear a live demo!
import mahotas as mh

def method1(image, sigma):
    image = mh.imread(image)[..., 0]
    image = mh.gaussian_filter(image, sigma)
    binimage = (image > image.mean())
    labeled, _ = mh.label(binimage)
    return labeled

mahotas is my computer vision/image processing package.
Segmentation Methods In Demo

Methods Under Study

1. Threshold with Otsu
2. Threshold with mean

Neither of these methods is very good!

They are easy to explain & demo.

Read our paper for what methods actually work.

(or just come talk to me).

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Methods Under Study

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This is a Demo!

- Neither of these methods is very good!
- They are easy to explain & demo
- Read our paper for what methods actually work. (or just come talk to me).
Writing a jugfile

jugfile.py

```python
from jug import TaskGenerator

@TaskGenerator
def method1(image, sigma):
    ...
```
Your code can be in multiple files

segmentation.py

```python
import mahotas as mh

def method1(image, sigma):
    ...
```

jugfile.py

```python
from jug import TaskGenerator
from segmentation import method1

method1 = TaskGenerator(method1)
```
from glob import glob
inputs = glob('images/*.
results = []
for im in inputs:
    m1 = method1(im, 2)
    m2 = method2(im, 4)
    ref = im.replace('images', 'references') \ 
        .replace('jpg', 'png')
    v1 = compare(m1, ref)
    v2 = compare(m2, ref)
    results.append((v1, v2))

The above code looks like pure Python!
Also, ask questions...
By the way, if you’re following at home, (i.e., downloaded the slides); you can see the code on github.
@TaskGenerator
def double(x):
    return x*2

four = double(2)
eight = double(four)

converts to

def double(x):
    return x*2

four = Task(double, 2)
eight = Task(double, four)
def hash_of(task):
    return crypto_hash(
        {task.function, task.args, task.kwargs})

- If task.args are other tasks, recurse!
- That’s pseudo-code
- Real-life code slightly more complex
The task hash encodes whole computation path

@TaskGenerator
def double(x):
    return x*2

four = double(2)
eight = double(four)

- four encodes double(2)
- eight encodes double(double(2))
def maybe_run_task(task, backend):
    h = task.hash()
    if backend.can_load(h):
        # Nothing to do
        return

    # Same thing for kwargs
    return f(*args)
Running a Task

```python
def maybe_run_task(task, backend):
    h = task.hash()
    if backend.can_load(h):
        # Nothing to do
        return

    f = task.function
    args = []
    for a in task.args:
        if is_immediate_value(a):
            args.append(a)
        else:
            args.append(backend.load(a.hash()))

    # Same thing for kwargs
    return f(*args)
```

Again, this is pseudo-code
Two Backends Are Available

Filesystem

- Default backend
- Carefully designed to work on NFS
- Anything pickle()-able can be used as Task output/input.
- Numpy arrays are special-cased (for speed and disk-space savings).

Redis (NoSQL Database)

- Redis is a file-backed store
- Ideal for many small “files”
- All workers talk to same database
Jug Processes are Separate Processes!

- No GIL (Global Interpreter Lock) issues
- Can run on separate machines
- Do not need to start at the same time
You fix a bug in `method1`.

Now, you need to recompute all `method1` calls.

Also, `print_results`
Jug Enhances Reproducibility

Typical Dark Side of Computational Analysis

- “What was the parameter that generated this result? I think it was $\frac{1}{2}$, right? Had to be.”
- “Deleted the intermediate results, reran; now everything is different.”
- “We cannot reproduce the table in our own paper.”

Advantages of Jug

- With jug, changing parameters will trigger recomputation of all downstream results.
- jug invalidate handles all dependencies
- Unlike make, you can use any Python function
How Much is Jug Used?

- It started as stereotypical scratch an itch software: I wrote it because I needed it
- Not very widely used at the moment
- Slowly picking up (by now 4.5 years old)
- 43,000 PyPI downloads
  Was at 13,000 than a year ago
Summary

Jug is Good For

- Coarse tasks (at least 1 second, ideally a few more)
- Data that fits on one disk
- Fan-out/Reduce/Fan-out modes
- Batch systems with shared network filesystems

Jug is Not Appropriate For

- Parallelization at micro level
- Data that does not fit in one disk
Finding Out More About Jug...

- [http://metarabbit.wordpress.com](http://metarabbit.wordpress.com)
  My blog, latest posts are about jug
- [http://github.com/luispedro/jug](http://github.com/luispedro/jug)
  the code
- [http://jug.rtfd.org](http://jug.rtfd.org)
  read the fine documentation
- [http://groups.google.com/group/jug-users](http://groups.google.com/group/jug-users)
  google mailing list
- [http://luispedro.org/software/jug](http://luispedro.org/software/jug)
- luis@luispedro.org