CPU Load Experiments

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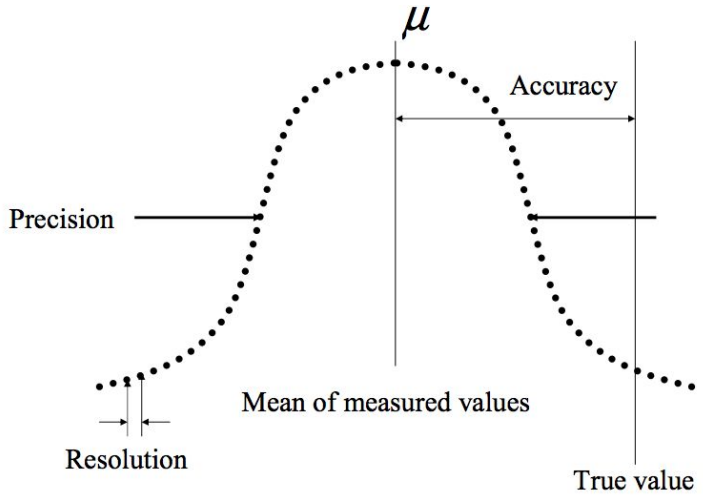
Sources of error

- Random Error
  - Unpredictable (At least very hard to control)
  - Non-deterministic
  - Unbiased
  - E.g. Noise in a copper wire telephone communication, anything that can be approximated with a Gaussian of mean zero
  - Avoided by statistical analysis
- Systematic Error
  - Result of an experimental “mistake”
  - Avoided by control through skill of experimenter
  - Produces a constant or slowly varying biased
  - E.g. Forgetting to clean cache

More on Errors

- Systematic errors are unfairly called ERRORS, some of them are rather overlooks by experimenter. (Mytkowicz et al.)
- Holistic conclusions made about the system based on a small sample of local data or in computer science terms, a very specific experimental setup.



What source of error is the CPU Load?

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1. Random Error
    a. Hard to control or predict processes
    b. The OS is a very complicated intricate system with many moving components.
2. Systematic Error
    a. Well, we can control some aspect of it. How?
    b. There are two solutions:
        i. Turn off wifi connections, kill any process taking a lot of CPU, get into the system deamons and kill some of those.
        ii. Completely characterize CPU load. I.e. For each benchmark, know the run-time for 50%, 70%, >50% but less than 70% etc.
            1. Requires having a system to control CPU load at a given point of time
            2. Also assumes ideally a complete control of the CPU load
            3. With these, results can be published where we would think of each CPU Load percentage as a different experimental setup

Let's take a step back

What is the CPU load?

- CPU has certain, limited processing power
  - Processes are scheduled by priority, to ensure each process is treated fairly, they are given a "quantum" of time to run, before being placed back in the run queue.
  - Two Times: user time, system time.

How do we calculate it?

```
static computeMeanCpu(start,end) {
    //Calculate the difference in idle and total time between the measures
    var idleDifference = end.idle - start.idle;
    var totalDifference = end.total - start.total;
    //Calculate the average percentage CPU usage
    var percentageCPU = 100 - (100 * idleDifference / totalDifference);
    return Number(percentageCPU.toFixed(2));
}
```

The Experiment...

What do we hope to achieve?

- Determine if there is a correlation between CPU load and running time.
- Integrate it into wu-wei, perhaps as a sort of flag to the experimenter.
- Learn a lesson and have this present whenever we benchmark.

Procedure to get good results - First Try

- **Idea**
  - Measure two points before/after benchmark, take average from that
  - To get measurements of different CPU load levels, continue along with my daily activities.
- **Problem**
  - Two points is not enough to characterize CPU, might have a case where the CPU varies a lot while the benchmark is running, (specially since I am taking the approach of randomly varying it)
  - CPU load is too sensitive, right before and right after might not be a good characterization with wu wei running

Procedure to get good results - Second Try

- **Idea**
  - Make COMPLICATED system of promises, measure a few points before, a few points after, and during the benchmark execution
  - Again, to gather measurements of different CPU load levels, continue along with my daily activities as benchmarks are running
- **Improvements**
  - A little bit more data!!!
  - Characterization of actual benchmark CPU load is beginning to form
- **Problems**
  - Did not distinguished between before, during and after points, assumption was that the actual benchmark would not induce a very high cost on the CPU load
  - As with the previous approach, the assumption of “continuing with daily life” let to bad characterizations of CPU-load, the longer the runtime of the benchmark, the more likely fore the measurement to be incorrect.

Procedure to get good results - Third Try

- **Idea**
  - Collect CPU load at all times during experiment
  - No need for promises, open synchronous processes that hold the execution of wu-wei for 5 secs, before and after benchmark
  - Collect data also during the benchmark in order to characterize benchmark CPU load
  - Still collect data at random.
- **Improvements**
  - This data was pretty good, gave a pretty good idea of CPU load vs. time,
  - Gave a decent and noticeable enough characterization of benchmark.
- **Problems**
  - Not all benchmarks had data for certain CPU-loads, did not allow to make complete conclusions about all benchmarks
  - Still not controlling the CPU-load introduces a systematic error due to the fact that averages are computed

Procedure to get good results - Finally...

- CPU traces from previous trail give a pretty good idea of CPU load per benchmark
- **Idea**
  - Well, now that we know a good estimate of how much CPU load a given benchmark induces, use one of them to control and drive CPU load. Therefore, use benchmark as a background process to raise and lower CPU.
  - No need to randomly collect points anymore, turn off, wifi, kill other processes, make sure to control as much of the system in that sense as possible.
  - Perform experiments at 40%, 60%, and 80% CPU-load.
- **Results**
  - Wallah!!!