MATLAB EXPO
FRANCE

8 octobre 2024 | Paris

MATLAB, les bonnes pratiques

Master Class

Pierre HAROUIMI, MathWorks

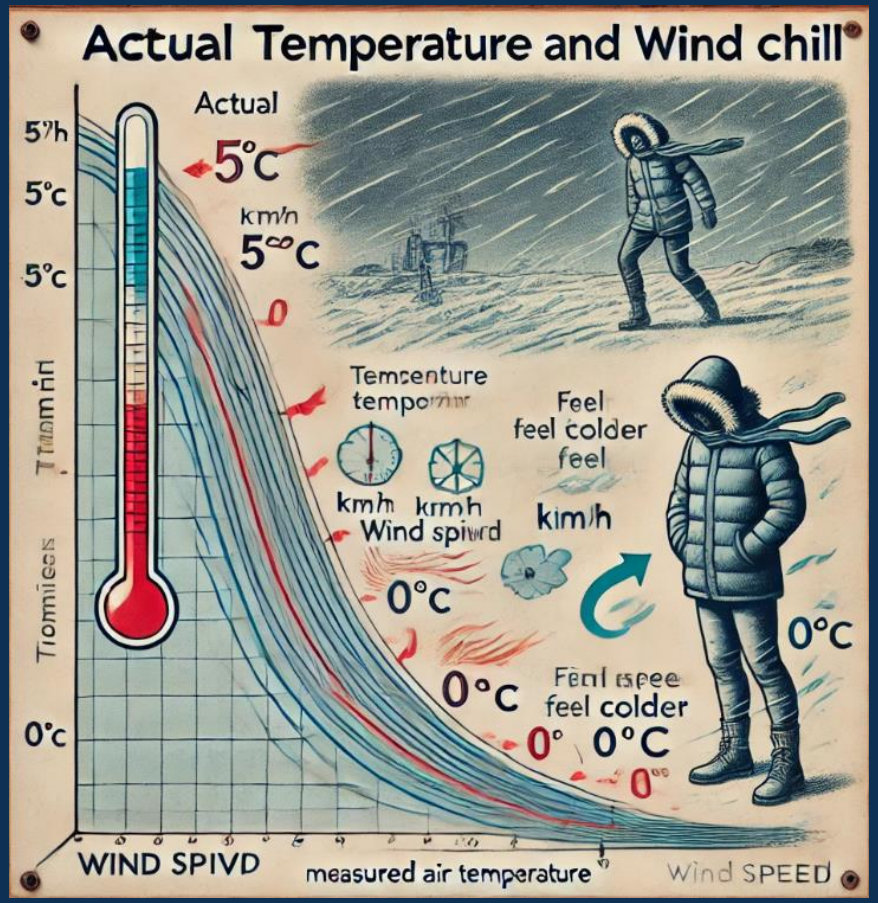
Application Engineer

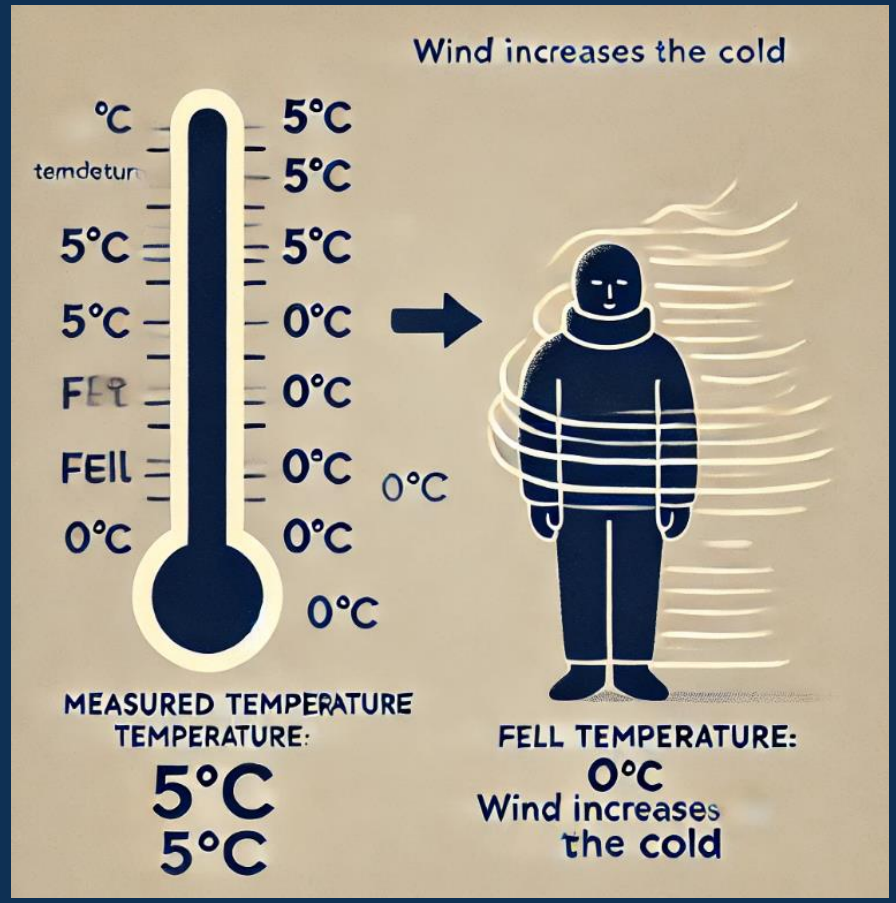
Romain DUVAL, MathWorks

Application Engineer

MathWorks

Today's goal





Source: images generated with chatGPT

Today's goal

Calculate the perceived temperature with the following very *complex* formula:

$$[T_{\text{perceived}} \approx T_{\text{air}} - 0.7 \times V^{0.5}]$$

Wind

MATLAB code example

```
% Read Excel file - Trigger not recommended function
data = xlsread("weatherData.xlsx");

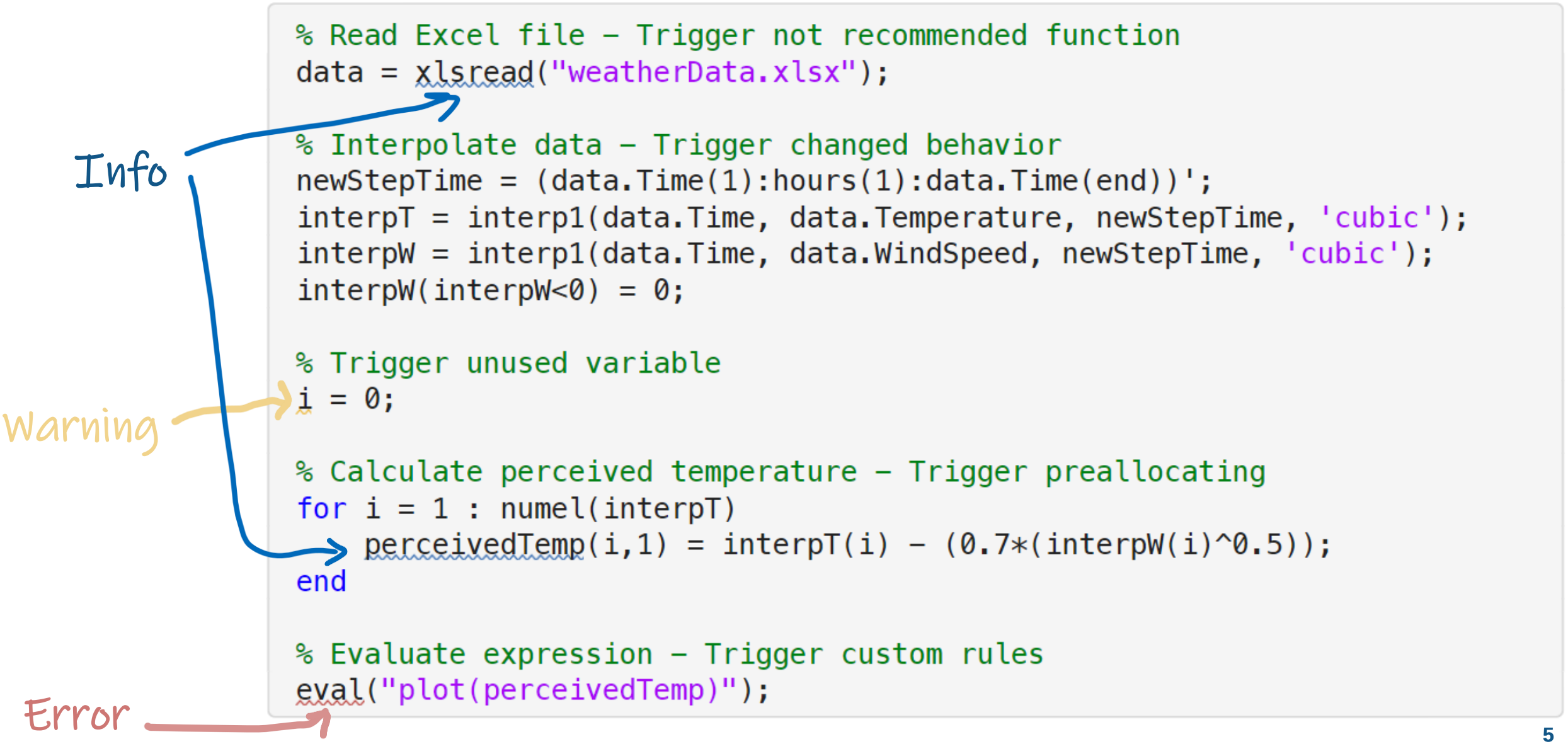
% Interpolate data - Trigger changed behavior
newStepTime = (data.Time(1):hours(1):data.Time(end))';
interpT = interp1(data.Time, data.Temperature, newStepTime, 'cubic');
interpW = interp1(data.Time, data.WindSpeed, newStepTime, 'cubic');
interpW(interpW<0) = 0;

% Trigger unused variable
i = 0;

% Calculate perceived temperature - Trigger preallocating
for i = 1 : numel(interpT)
    perceivedTemp(i,1) = interpT(i) - (0.7*(interpW(i)^0.5));
end

% Evaluate expression - Trigger custom rules
eval("plot(perceivedTemp)");
```

MATLAB code example

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% Evaluate expression - Trigger custom rules
eval("plot(perceivedTemp)");
```

What are your main concerns?

« My code is very sensitive to **changes** »

« I don't know how to **optimize** my code »

« Each **upgrade** of a MATLAB release is very painful »

« It is hard to **maintain** a code with thousands of lines »

« Writing **tests** seems to be complicated »

Streamlining code development

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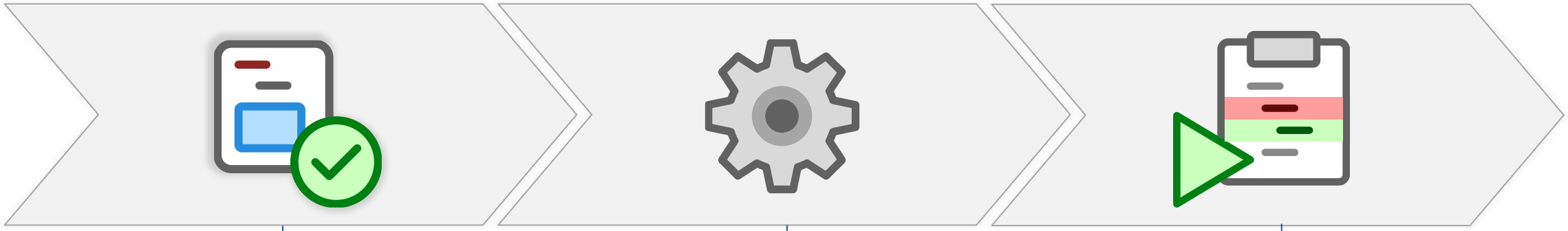
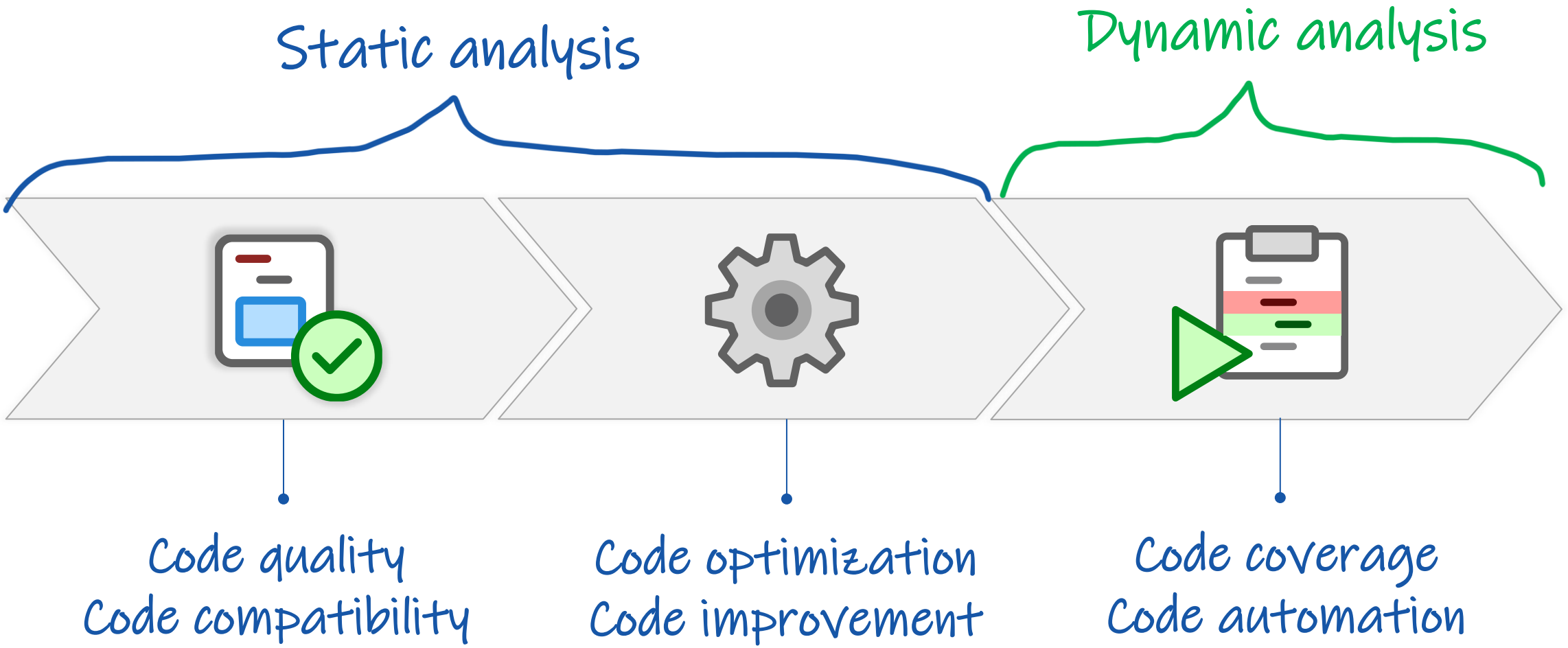


Code quality
Code compatibility

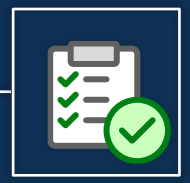
Code optimization
Code improvement

Code coverage
Code automation

Streamlining code development



Code analysis



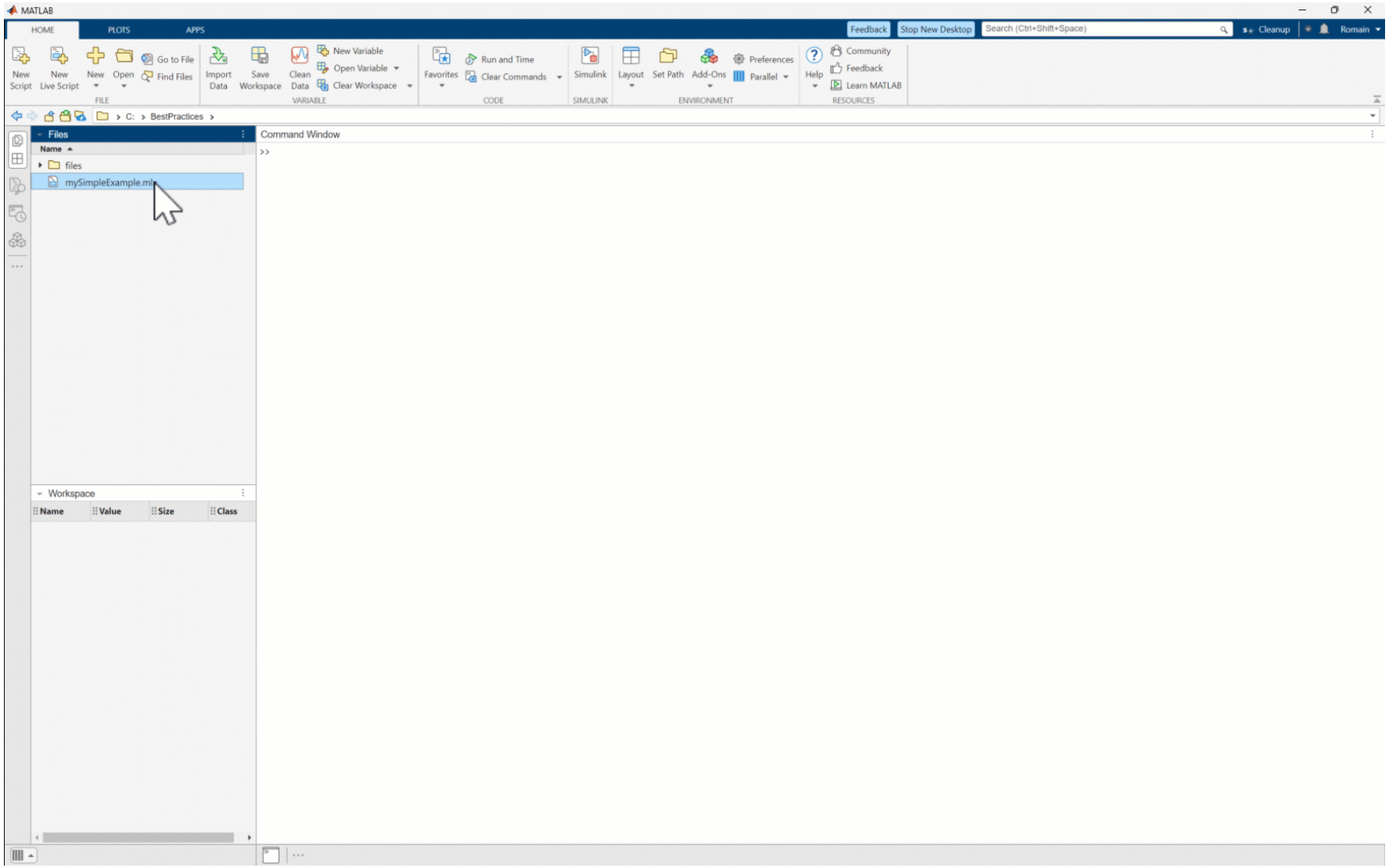
How to ensure code quality?

How to standardize code analysis?

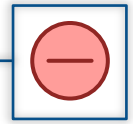
How to properly upgrade my code?

Static analysis with Code Analyzer

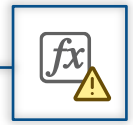
* Proactive code checking
* Code review accelerator
* Code practice standardization
* Reporting
* Can be automated



Code **Compatibility** Analyzer: What does MATLAB check?

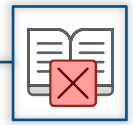


Functionalities that has been or will be removed



Functionalities that has changed or will change behavior

New functionalities that might improve code



Unsupported functionality that might cause errors

Code Compatibility Report

Code Compatibility Analyzer

Analysis Date: 9/24/2024, 5:46:53 PM

Active Issues Only

MATLAB Release: R2024b

1	0	2	1
Total Files Analyzed	Error	Warning	Info

Code Health Details

expand all

Filter by Text | Group by Issue Type | Filter by Severity | Filter by Issue Type

Suggested Improvements (1)	Help
'xlsread' is not recommended. With appropriate code changes, use 'readtable', 'readmatr...	

Behavior Changes (2)	Help
'interp1(...,'cubic')' changed in R2020b to perform cubic convolution. To continue using s...	

Code Compatibility Report

(Overlap with Code Analyzer)

New message

Code Compatibility Analyzer

Analysis Date: 9/24/2024, 5:46:53 PM

Active Issues Only

MATLAB Release: R2024b

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Error

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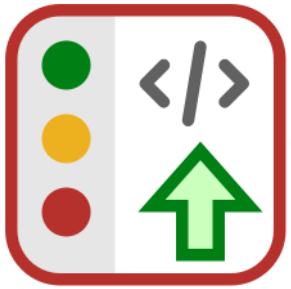
Automatization



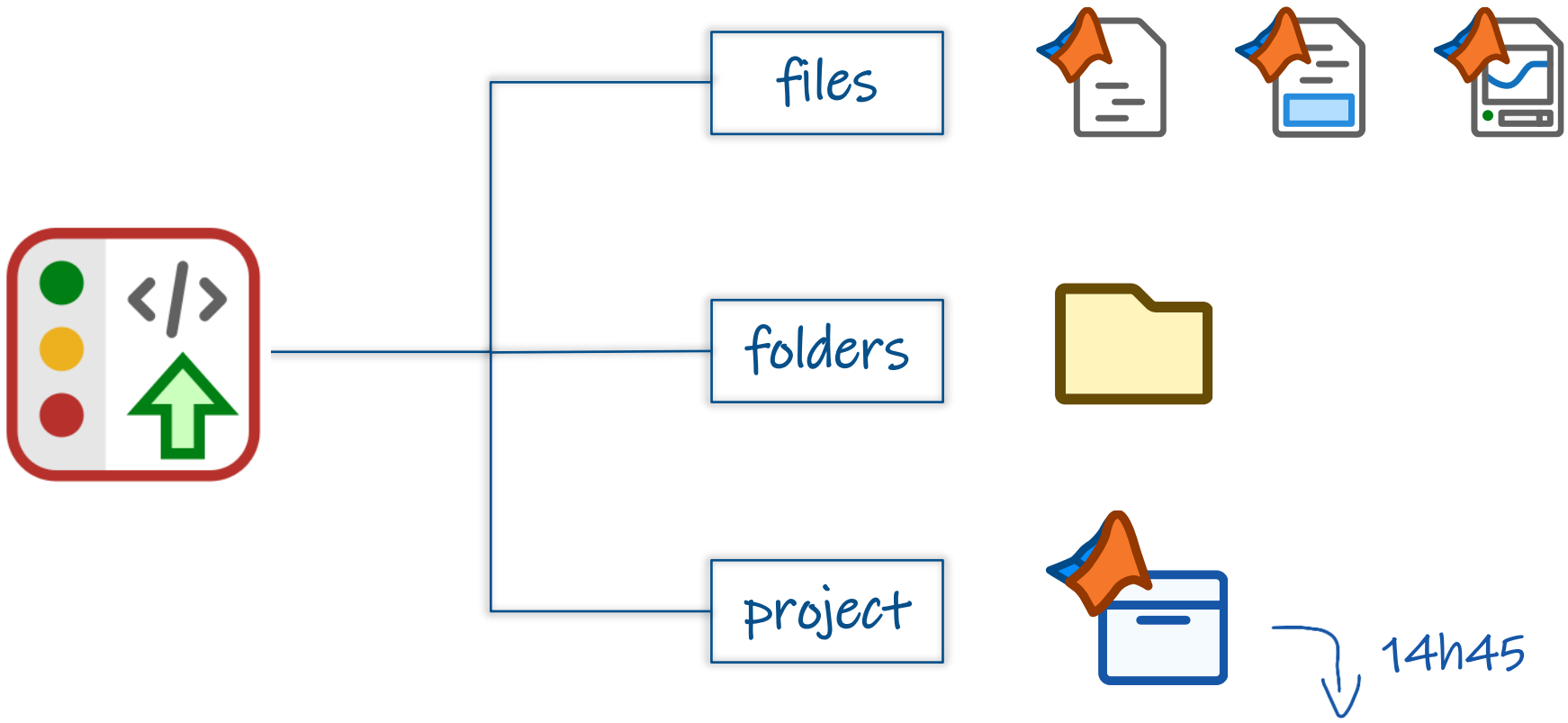
```
results = analyzeCodeCompatibility
```

```
results.Recommendations
```

ans = *3×8 table*

	Identifier	Desc
1	INTRPC	"'interp1(...,'cubic')' changed in R2020b to pe
2	INTRPC	"'interp1(...,'cubic')' changed in R2020b to pe
3	XLSRD	"'xlsread' is not recommended. With appropr

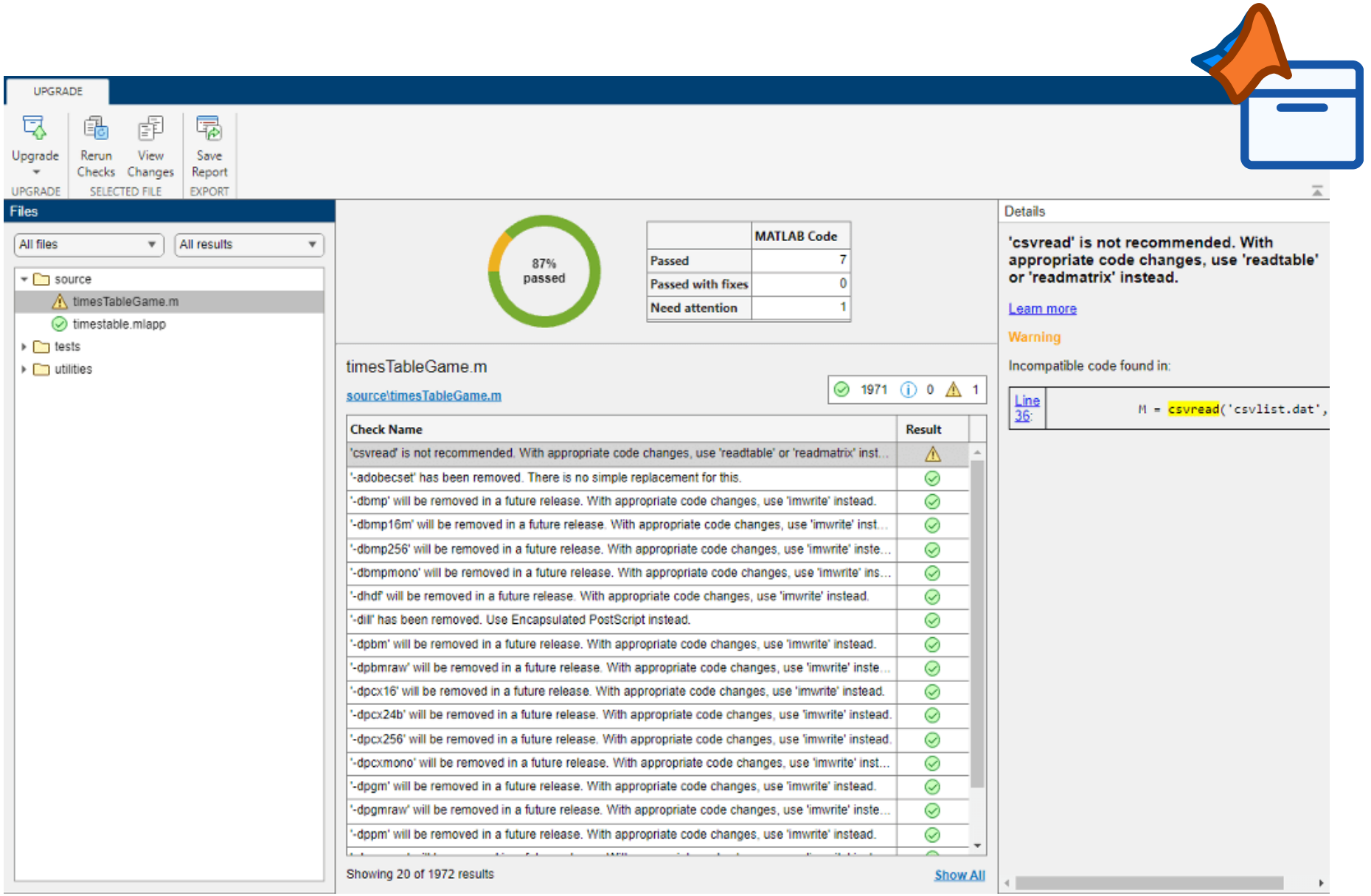
Code Compatibility for your projects



Master Class : Usine logicielle, industrialisez vos développements avec MATLAB et Simulink

Michelle Valente, *MathWorks*
Maxime François, *MathWorks*

Upgrade tool



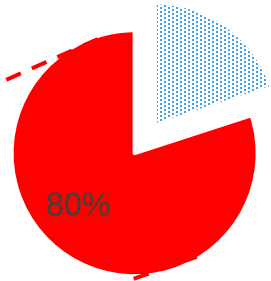
Code optimization

How to target performance critical code?

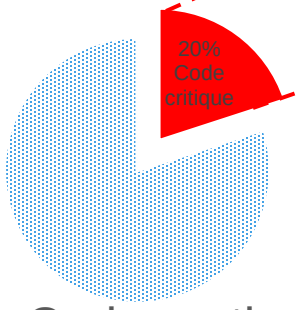
What are some of the optimization technics?

Empirical Pareto principle

Execution time
Memory usage



- Optimizing a complete software is easy
- No need for performance-oriented development



Code portion

- Critical code already optimized
- Critcal code is scattered
- Change impact all the code
- Initial performance too poor

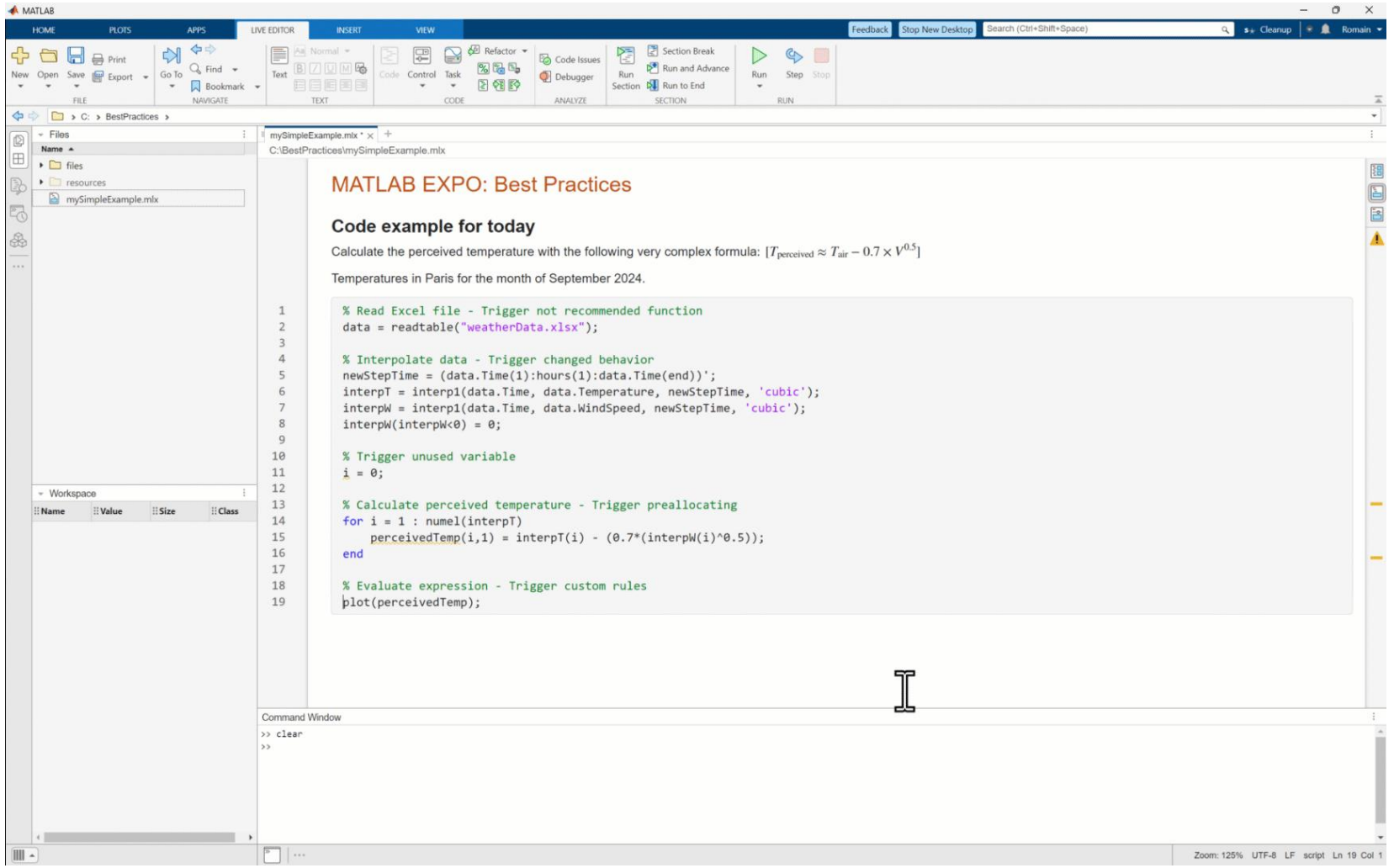
Profiler MATLAB : "A graph is worth a thousand words."

* Overview of execution by callstack
- Code structure
- Quickly identify bottleneck

* Traceability

* Programmatical approach

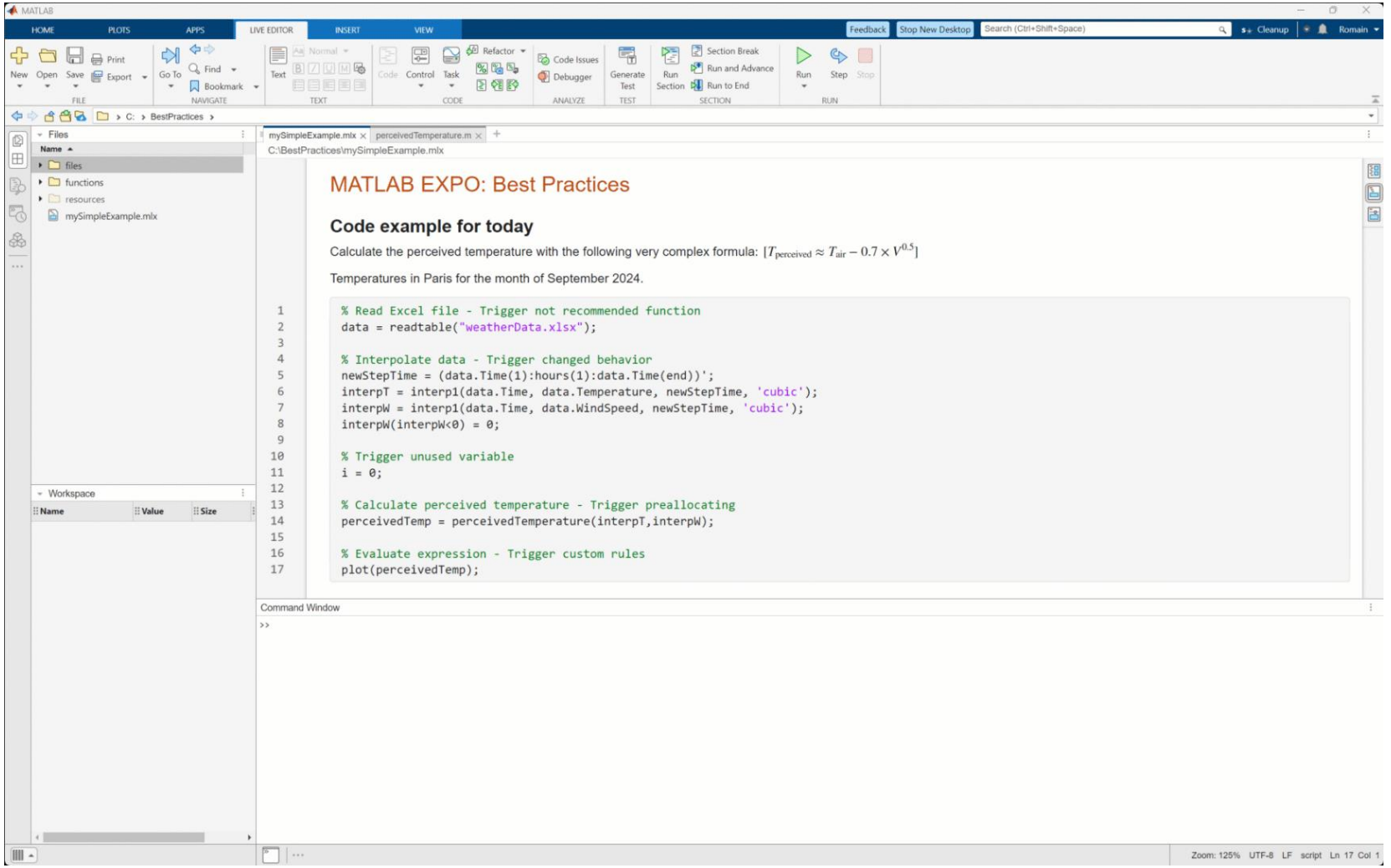
```
profile on;
<function to benchmark>
profile viewer;
```



Benchmark technics

Benchmark should be performed with:

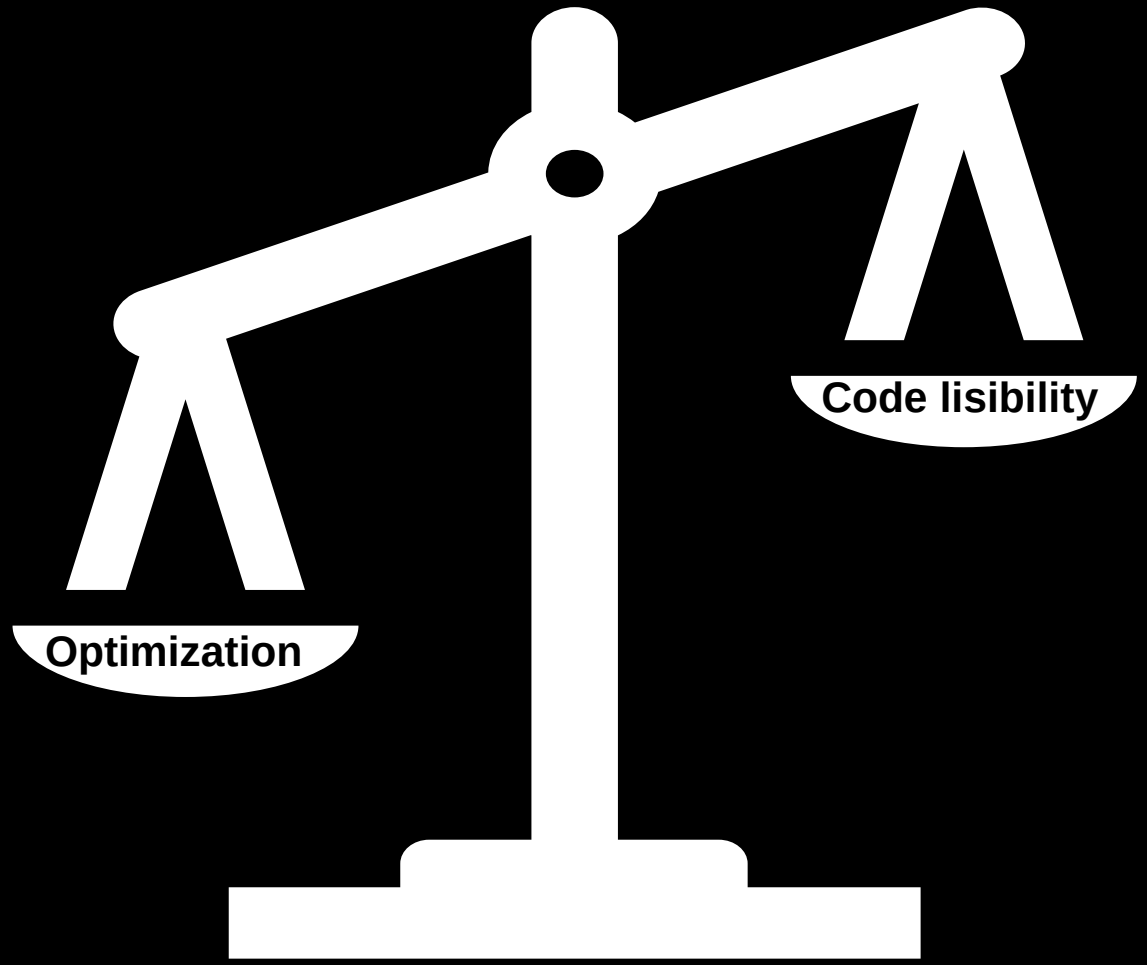
- Clean/ Defragged computer
- No concurrent running programs



Preliminary checklist

- [x] Recent version of MATLAB
- [x] Create functional code
- [x] Minimize file I/O
- [x] Reuse graphical component / libraries when possible
- [x] Avoid displaying into Command Window
- [x] Avoid Clear all, introspection, evaluation functions [dbstack | exist | whos | eval | feval(fname)]
- [x] Do not use data as code

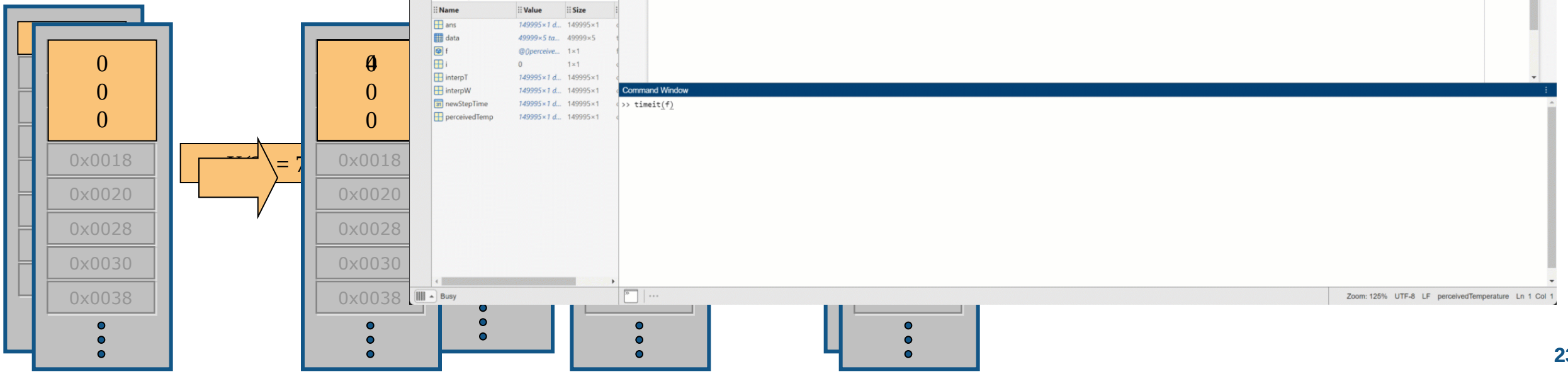
/!\ DISCLAIMER /!\



DEVELOPER DISCRETION IS ADVISED

Préallocation

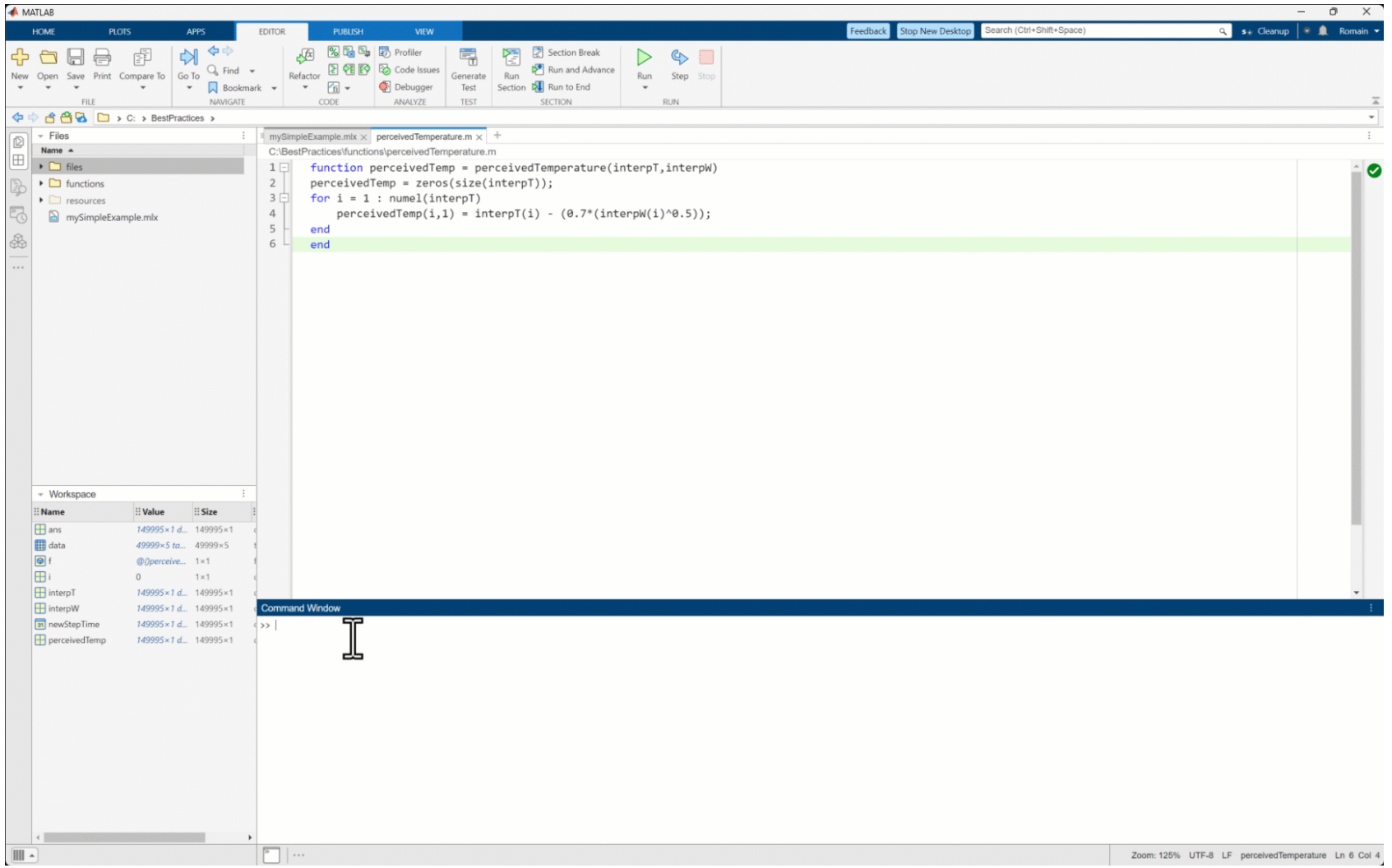
```
x = zeros(3,1)
x(1) = 4
x(2) = 7
x(3) = 12
```



Loop vs Vectorization

$$h_\theta\left(x^{(i)}\right) = \theta_0 x_0^{(i)} + \theta_1 x_1^{(i)} + \cdots + \theta_j x_j^{(i)}$$

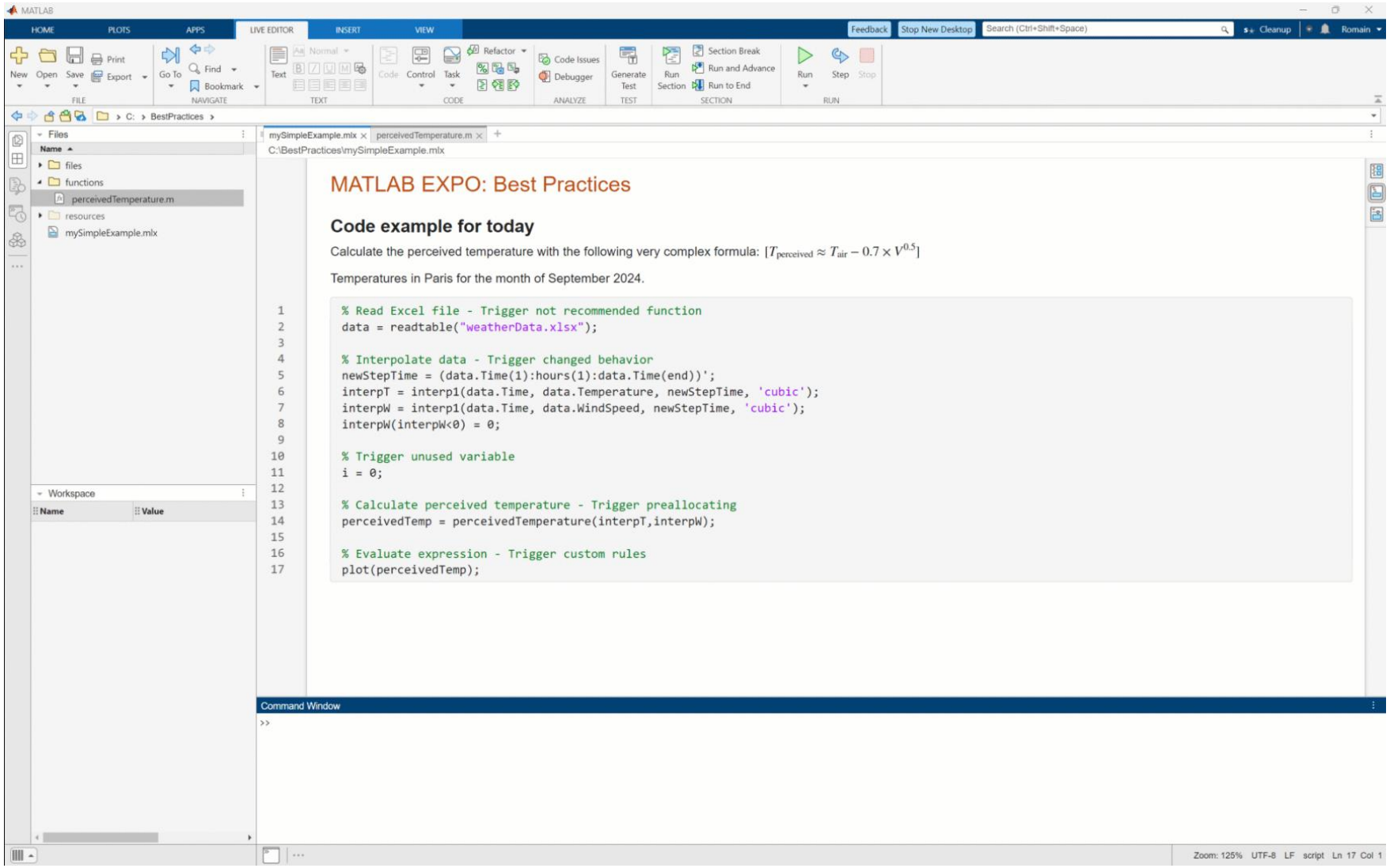
$$\theta^T x^{(i)} = [\theta_0 \theta_1 \ldots \theta_n] \begin{bmatrix} x_1^{(i)} \\ x_1^{(i)} \\ \ldots \\ x_1^{(i)} \end{bmatrix}$$



Arguments validation

* What if the code is meant to be shared?

* Works for outputs too!

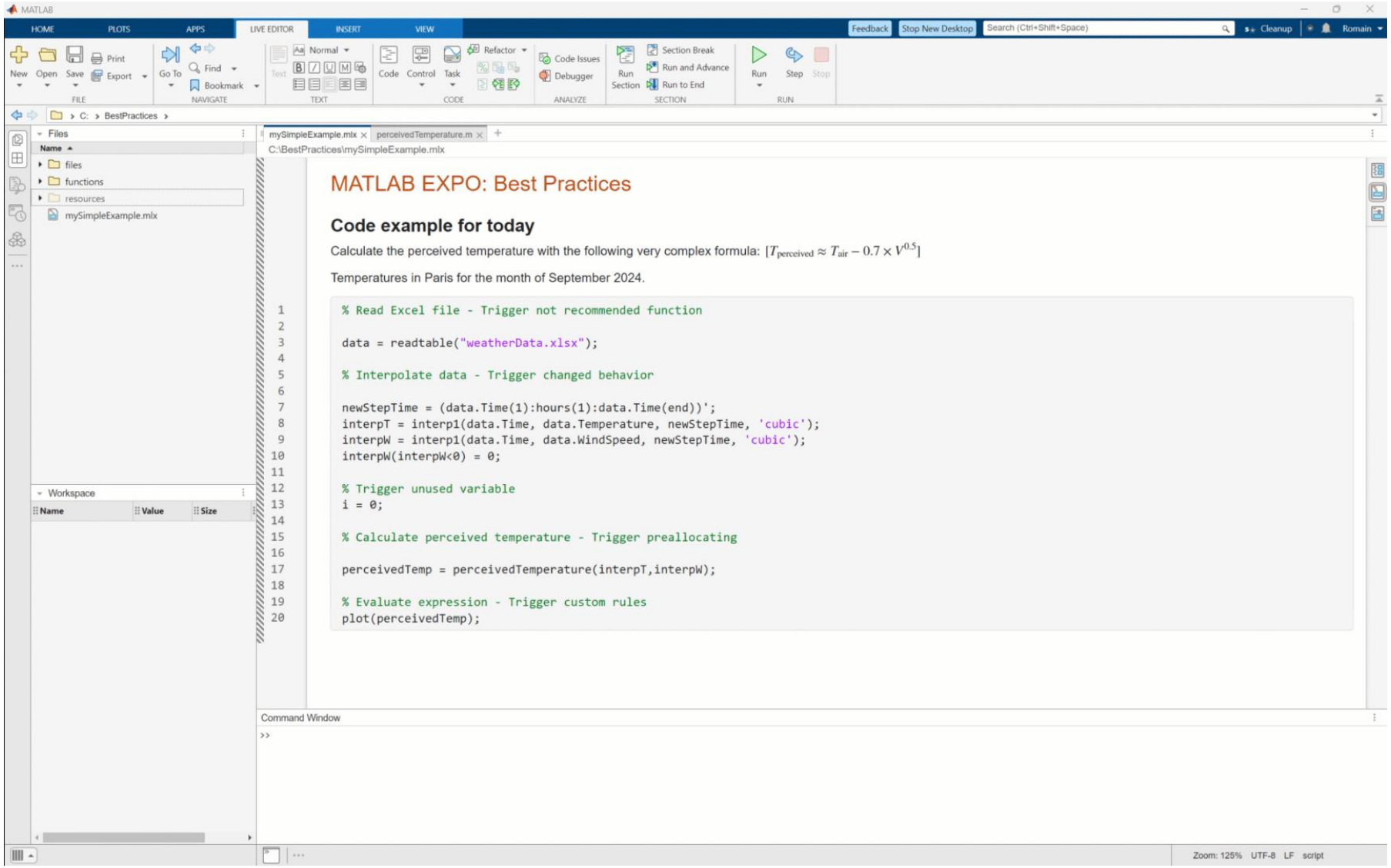


Parallelization : divide and conquer

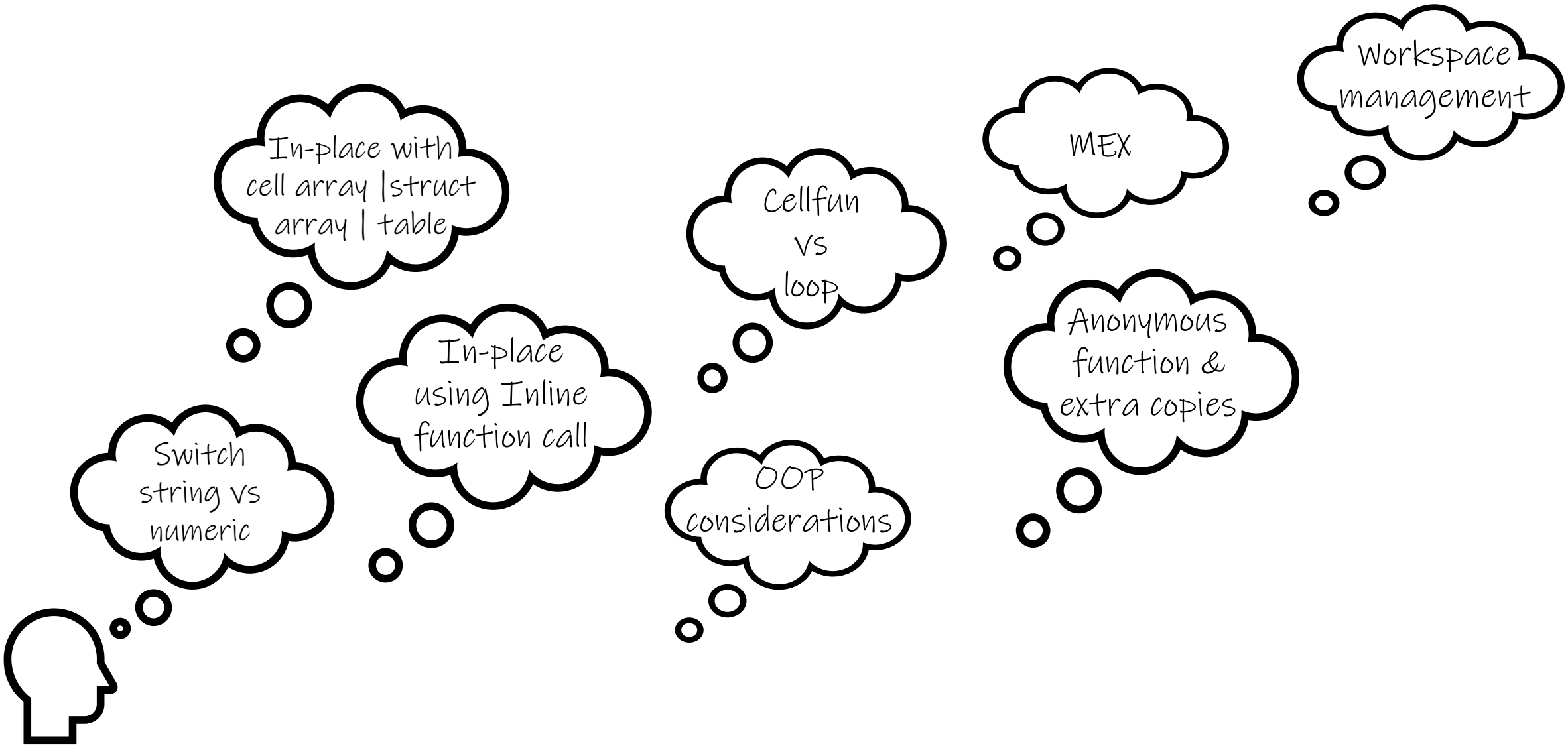
+ Modern computers are multicores
+ OS support multithreading
+ Common tasks are time-consuming
  - File IO
  - Result display
  - Lengthy calculation no vectorizable
  - ...
+ Tasks independent

---

asynchronous execution

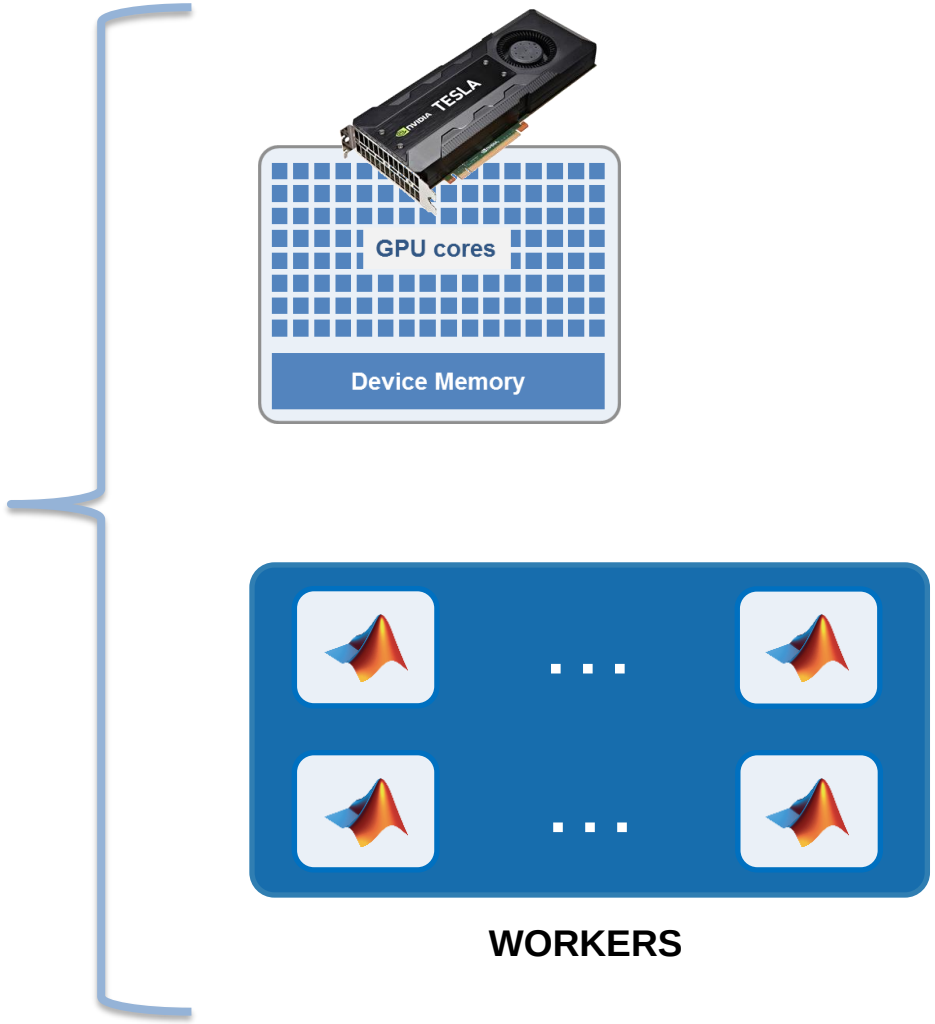


We could also have mentioned….



What else? …Unleash the power of parallelism

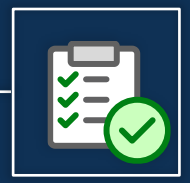
MATLAB
Parallel Computing Toolbox



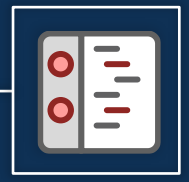
WORKERS

"Make my code work, Make my code work"

Testing



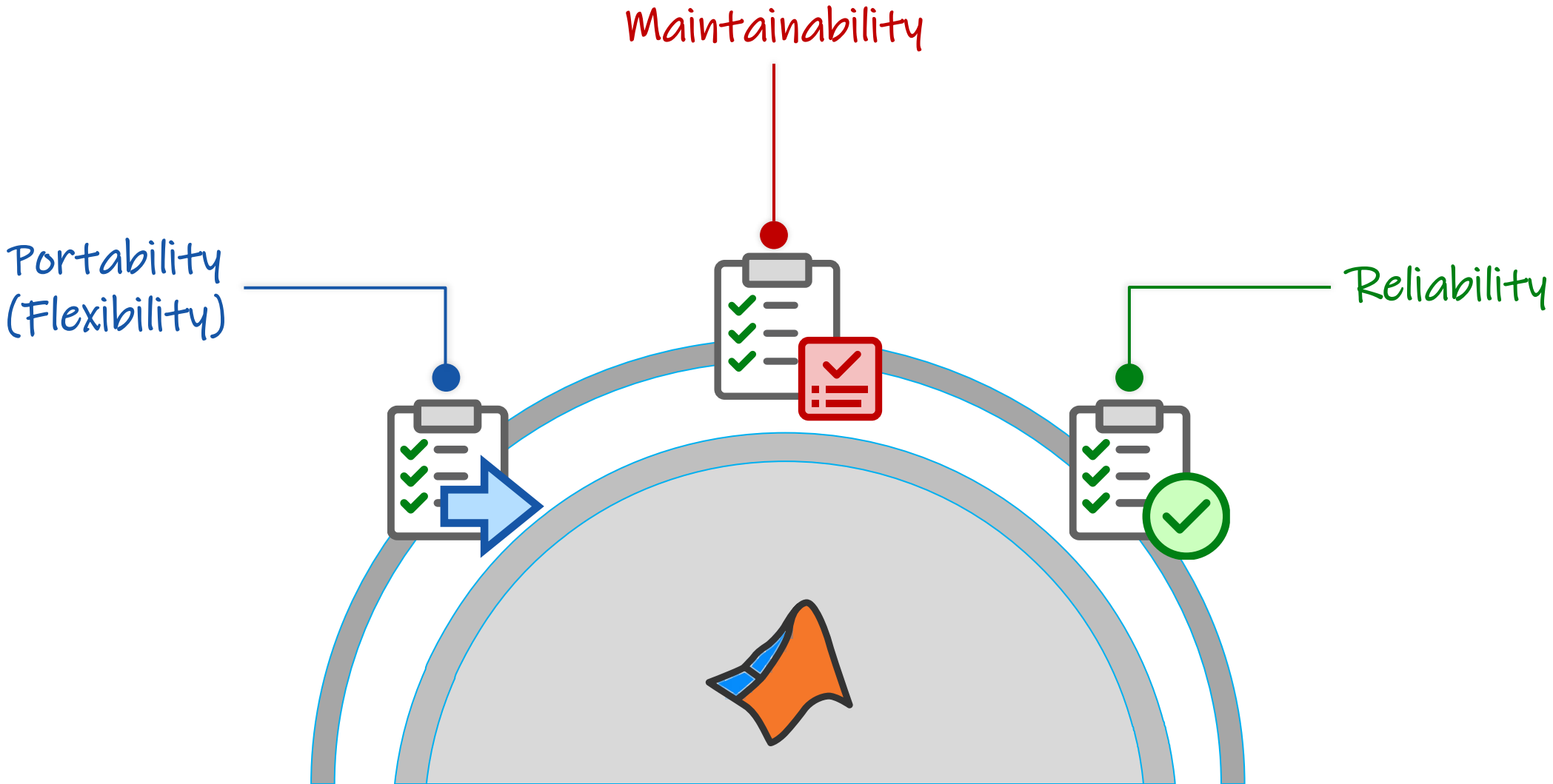
How to continuously maintain my code?



How to prevent breaking changes?

Is my code portable?

Software Product Quality: **Maintainability, portability, reliability**



MATLAB

HOME PLOTS APPS PROJECT EDITOR PUBLISH VIEW

Feedback Stop New Desktop Search (Ctrl+Shift+Space) Pierre

New Script | New Live Script | New | Open | Go to File | Find Files — FILE
Import Data | Save Workspace | Clean Data | New Variable | Open Variable | Clear Workspace — VARIABLE
Favorites | Run and Time | Clear Commands — CODE
Simulink — SIMULINK
Layout | Set Path | Add-Ons | Preferences | Parallel — ENVIRONMENT
Help | Community | Feedback | Learn MATLAB — RESOURCES

OneDrive › ByProject › Events › MATLAB EXPO › MATLAB EXPO 2024 › Presentation_BestPractices ›

perceivedTemperature.m

C:\Users\pharouim\OneDrive - MathWorks\ByProject\Events\MATLAB EXPO\MATLAB EXPO 2024\Presentation_BestPractices\functions\perceivedTemperature.m

```
1  function temp = perceivedTemperature(T,W)
2  arguments
3      T (1,:) double
4      W (1,:) {mustBeNonnegative}
5  end
6  temp = T - 0.7*W.^0.5;
7  end
```

Workspace
Name | Value

Debugger
Breakpoints
Pause on E...
Pause on ...
Pause on N...
Pause on O...
Function call stack
Not paused in debugger

Command Window
>>

Zoom: 175% UTF-8 LF perceivedTemperature Ln 6 Col 23

Equivalence testing

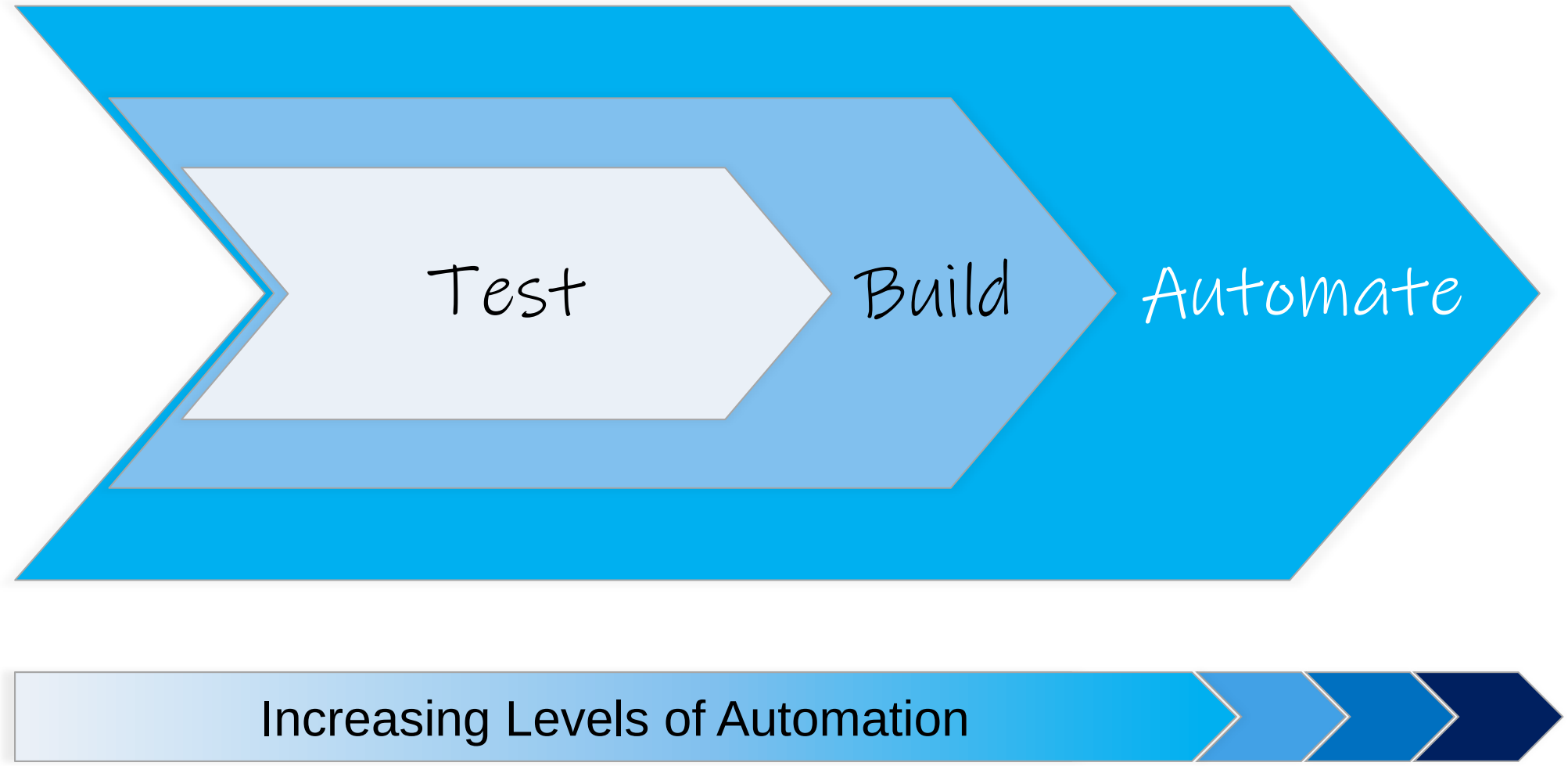
=> Test package deployment and code generation in 3 lines

Example with Python package deployment

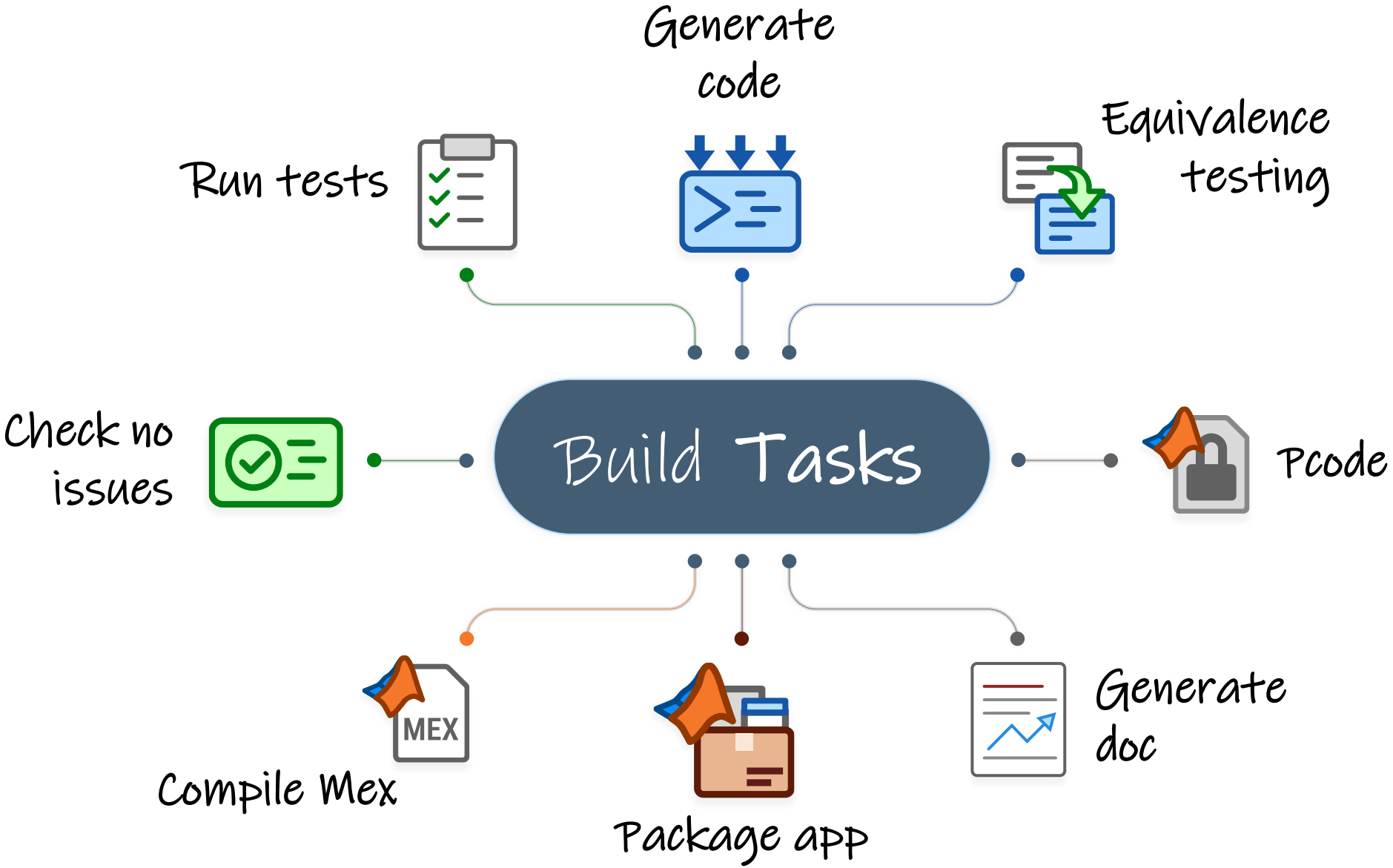
```
% Equivalence test
classdef tDeployment < matlabtest.compiler.TestCase
    methods(Test)
        function pythonEquivalence(testCase)
            buildResults     = build(testCase,"perceivedTemperature.m","pythonPackage");
            executionResults = execute(testCase,buildResults,{[20 40]});
            verifyExecutionMatchesMATLAB(testCase,executionResults);
        end
    end
end
```

Build **Execute** **Verify**

MATLAB's evolving solutions for test & automation



Build multiple tasks…



Build multiple tasks… and automate them

```
plan = buildplan;
plan("check")       = CodeIssuesTask();
plan("test")        = TestTask();
plan("equivalence") = EquivalenceTask()
```

Define tasks

```
plan =
  Plan with tasks:

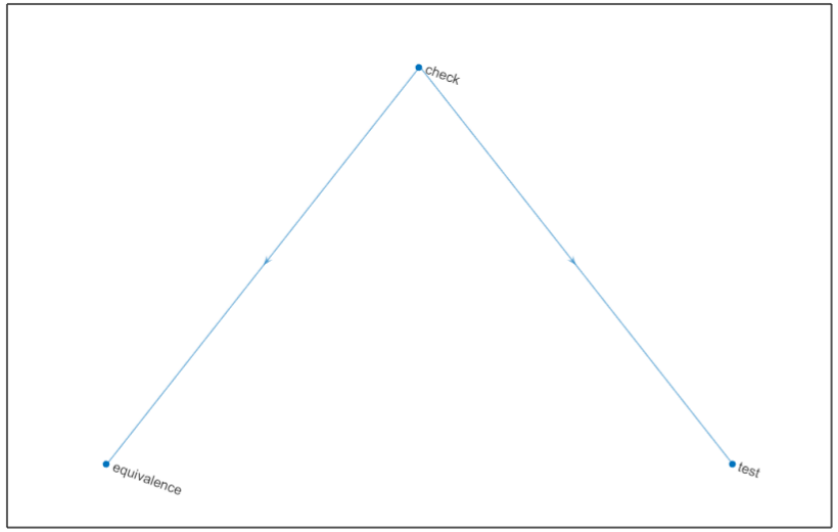
    check       - Identify code issues
    equivalence - Verify deployed code artifact and the MATLAB source code match
    test        - Run tests
```

Build multiple tasks… and automate them

```
plan = buildplan;
plan("check")       = CodeIssuesTask();
plan("test")        = TestTask();
plan("equivalence") = EquivalenceTask()
```

Define tasks

```
plan.DefaultTasks            = "check";
plan("check").Dependencies = ["test","equivalence"];
plot(plan)
```



Define dependencies

Build multiple tasks… and automate them

```
run(plan)
```

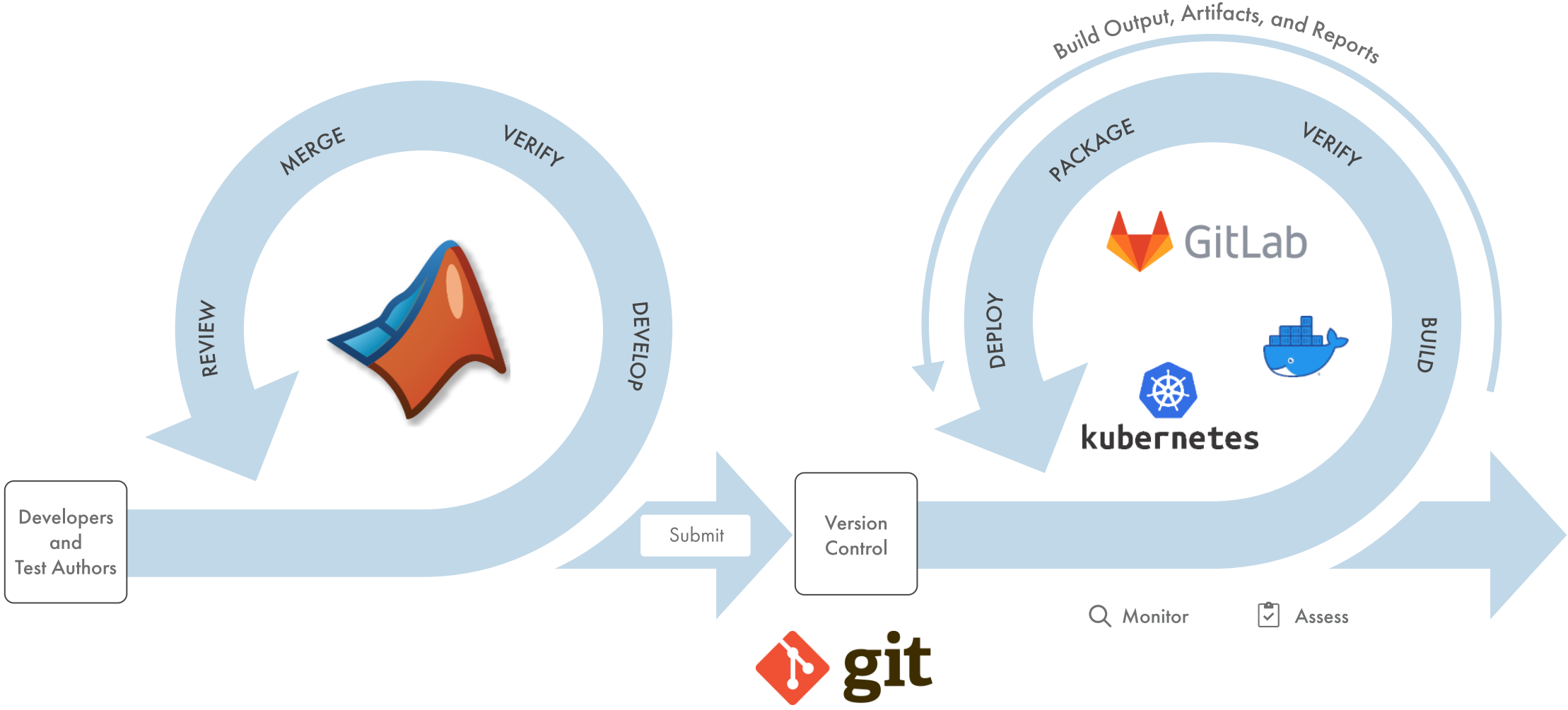
```
** Starting test
Not possible
.

Test Summary:
    Total Tests: 1
         Passed: 1
         Failed: 0
     Incomplete: 0
       Duration: 0.029041 seconds testing time.

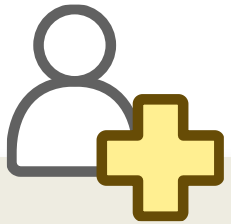
** Finished test

** Done equivalence
```

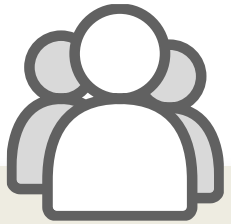
Automatize and industrialize your whole suite of tests in CI



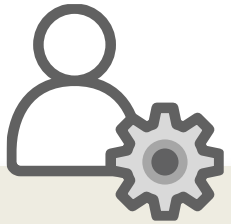
Next Steps



MathWorks
Engineers



MathWorks
Training



MathWorks
Consulting

Reach out for support to implement these practices in your projects

Pierre Harouimi
pharouim@mathworks.com

Romain Duval
rduval@mathworks.com

MATLAB EXPO
FRANCE

Thank you!

MathWorks®