

Seminář 11

Matlab a jiné programovací jazyky

- volání matlabu z jiného jazyka
- volání knihoven psaných v jiných jazycích
- převod matlab kódu do jazyka C/C++
- zabalení matlabových programů jako softwarové komponenty

Volání matlabu z jiného jazyka

Jazyky:

- C/C++ <https://uk.mathworks.com/products/matlab/matlab-and-c.html>
- Fortran <https://uk.mathworks.com/help/matlab/calling-matlab-engine-from-fortran-programs.html>
- Java - <https://uk.mathworks.com/help/matlab/matlab-engine-api-for-java.html>
- Python - <https://uk.mathworks.com/products/matlab/matlab-and-python.html>
- COM komponenty - <https://uk.mathworks.com/help/matlab/call-matlab-com-automation-server.html>
- .NET - <https://www.mathworks.com/help/matlab/call-matlab-from-net.htm>

Je nutné použít Engine aplikace (samostatné programy, které umožní z jiného jazyka zavolat matlabovské funkce)

Napišeme kód v Matlab API, pak ho přeložíme pomocí mex příkazu

Matlabovský kód můžeme z jiných jazyků volat pouze na strojích, kde je Matlab nainstalovaný.

Najdeme, kde je Matlab nainstalovaný

```
res = fullfile(matlabroot, 'bin', computer('arch'))
```

```
res =  
'C:\Program Files\MATLAB\R2024a\bin\win64'
```

Přidáme tuto cestu do systémové cesty (Nastavení -> systém -> O systému -> Upřesnit nastavení systému -> Proměnné prostředí)

Vytvoříme Windows engine application

registujeme Matlab jako COM server (k tomu je potřeba spustit Matlab jako administrátor)

```
!matlab -regserver
```

Matlab otevře command window. To zavřeme.

C/C++

Zkopírujeme příklad

```
copyfile(fullfile(matlabroot, 'extern', 'examples', 'eng_mat', 'engwindemo.c'), '.', 'f')
```

Abychom to mohli udělat, musíme mít práva zápisu.

Vytvoříme aplikaci

```
mex -v -client engine engwindemo.c
```

Verbose mode is on.

No MEX options file identified; looking for an implicit selection.

... Looking for compiler 'Intel Parallel Studio XE 2020 with Microsoft Visual Studio 2017 (C)' ...

... Looking for environment variable 'ICPP_COMPILER20' ...No.

Did not find installed compiler 'Intel Parallel Studio XE 2020 with Microsoft Visual Studio 2017 (C)'.

... Looking for compiler 'Intel Parallel Studio XE 2020 with Microsoft Visual Studio 2019 (C)' ...

... Looking for environment variable 'ICPP_COMPILER20' ...No.

Did not find installed compiler 'Intel Parallel Studio XE 2020 with Microsoft Visual Studio 2019 (C)'.

... Looking for compiler 'Intel oneAPI 2021 with Microsoft Visual Studio 2017 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2021 with Microsoft Visual Studio 2017 (C)'.

... Looking for compiler 'Intel oneAPI 2021 with Microsoft Visual Studio 2019 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2021 with Microsoft Visual Studio 2019 (C)'.

... Looking for compiler 'Intel oneAPI 2022 with Microsoft Visual Studio 2017 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2022 with Microsoft Visual Studio 2017 (C)'.

... Looking for compiler 'Intel oneAPI 2022 with Microsoft Visual Studio 2019 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2022 with Microsoft Visual Studio 2019 (C)'.

... Looking for compiler 'Intel oneAPI 2022 with Microsoft Visual Studio 2022 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2022 with Microsoft Visual Studio 2022 (C)'.

... Looking for compiler 'Intel oneAPI 2023 with Microsoft Visual Studio 2019 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2023 with Microsoft Visual Studio 2019 (C)'.

... Looking for compiler 'Intel oneAPI 2023 with Microsoft Visual Studio 2022 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2023 with Microsoft Visual Studio 2022 (C)'.

... Looking for compiler 'Intel oneAPI 2024 with Microsoft Visual Studio 2019 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2024 with Microsoft Visual Studio 2019 (C)'.

... Looking for compiler 'Intel oneAPI 2024 with Microsoft Visual Studio 2022 (C)' ...

... Looking for environment variable 'ONEAPI_ROOT' ...No.

Did not find installed compiler 'Intel oneAPI 2024 with Microsoft Visual Studio 2022 (C)'.

... Looking for compiler 'MinGW64 Compiler (C)' ...

... Looking for environment variable 'MW_MINGW64_LOC' ...No.

Did not find installed compiler 'MinGW64 Compiler (C)'.

... Looking for compiler 'Microsoft Visual C++ 2017 (C)' ...

... Looking for registry setting 'HKLM\SOFTWARE\Microsoft\VisualStudio\SxS\VS7' 15.0 ...No.

... Looking for registry setting 'HKCU\SOFTWARE\Microsoft\VisualStudio\SxS\VS7' 15.0 ...No.

... Looking for registry setting 'HKLM\SOFTWARE\Wow6432Node\Microsoft\VisualStudio\SxS\VS7' 15.0 ...No.

... Looking for registry setting 'HKCU\SOFTWARE\Wow6432Node\Microsoft\VisualStudio\SxS\VS7' 15.0 ...No.

Did not find installed compiler 'Microsoft Visual C++ 2017 (C)'.

... Looking for compiler 'Microsoft Visual C++ 2019 (C)' ...

... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').

... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.

... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[16.0,17.0)'

```
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[16.0,17.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[16.0,17.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[16.0,17.0)'
Did not find installed compiler 'Microsoft Visual C++ 2019 (C)'.
... Looking for compiler 'Microsoft Visual C++ 2022 (C)' ...
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Executing command 'set "vcroot=C:\Program Files\Microsoft Visual Studio\2022\Community"&for /f "delims= " %a in
... Looking for registry setting 'HKLM\SOFTWARE\Microsoft\Microsoft SDKs\Windows\v10.0' InstallationFolder ...No.
... Looking for registry setting 'HKCU\SOFTWARE\Microsoft\Microsoft SDKs\Windows\v10.0' InstallationFolder ...No.
... Looking for registry setting 'HKLM\SOFTWARE\Wow6432Node\Microsoft\Microsoft SDKs\Windows\v10.0' InstallationFolder ...No.
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for environment variable 'ProgramFiles(x86)' ...Yes ('C:\Program Files (x86)').
... Looking for file 'C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe' ...Yes.
... Executing command '"C:\Program Files (x86)\Microsoft Visual Studio\Installer\vswhere.exe" -version "[17.0,18.0)'
... Looking for file 'C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Auxiliary\Build\vcvarsall.bat' ...
... Looking for folder 'C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Auxiliary\Build' ...Yes.
... Looking for registry setting 'HKLM\SOFTWARE\Wow6432Node\Microsoft\Windows Kits\Installed Roots' KitsRoot10 ...Yes.
... Looking for registry setting 'HKLM\SOFTWARE\Wow6432Node\Microsoft\Windows Kits\Installed Roots' KitsRoot10 ...Yes.
... Executing command 'echo off&set "sdkversion="&(for /f %a IN ('dir "C:\Program Files (x86)\Windows Kits\10\include
Found installed compiler 'Microsoft Visual C++ 2022 (C)'.
Set PATH = C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808\bin\HostX64\x64;C:\Program Files
Set INCLUDE = C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808\include;C:\Program Files
Set LIB = C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808\lib\x64;C:\Program Files
Set LIBPATH = C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808\lib\x64;C:\Program Files
Options file details
-----
```

```

Compiler location: C:\Program Files\Microsoft Visual Studio\2022\Community\
Options file: C:\Program Files\MATLAB\R2024a\bin\win64\mexopts\msvc2022.xml
CMDLINE100 : cl /c /Zc:__cplusplus /Zp8 /GR /W3 /EHs /nologo /MD /O2 /Oy- /DNDEBUG /DMATLAB_DEFAULT_RELEASE=R2024a
CMDLINE200 : link /nologo C:\Users\marke\AppData\Local\Temp\mex_75247487041762_3344\engwindemo.obj /LIBPATH:"C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808\x-
CMDLINE300 : if exist "engwindemo.ilc" del "engwindemo.ilc"
COMPILER : cl
COMPFLAGS : /Zc:__cplusplus /Zp8 /GR /W3 /EHs /nologo /MD
COMPDEFINES : /DMATLAB_DEFAULT_RELEASE=R2024a /DUSE_MEX_CMD /D_CRT_SECURE_NO_DEPRECATED /D_SCL_SECURE_NO_DEPRECATED
MATLABMEX :
OPTIMFLAGS : /O2 /Oy- /DNDEBUG
INCLUDE : -I"C:\Program Files\MATLAB\R2024a\extern\include" -I"C:\Program Files\MATLAB\R2024a\simulink\include"
DEBUGFLAGS : /Z7
LINKER : link
LINKFLAGS : /nologo
LINKTYPE :
LINKEXPORT :
LINKEXPORTVER :
LINKLIBS : /LIBPATH:"C:\Program Files\MATLAB\R2024a\extern\lib\win64\microsoft" libmx.lib libmex.lib libmat.lib
LINKDEBUGFLAGS : /debug /PDB:"engwindemo.exe.pdb"
LINKOPTIMFLAGS :
OBJEXT : .obj
LDEXT : .exe
SETENV : set COMPILER=cl
        set COMPFLAGS=/c /Zc:__cplusplus /Zp8 /GR /W3 /EHs /nologo /MD /DMATLAB_DEFAULT_RELEASE=R2024a /DUSE_MEX_CMD
        set OPTIMFLAGS=/O2 /Oy- /DNDEBUG
        set DEBUGFLAGS=/Z7
        set LINKER=link
        set LINKFLAGS=/nologo /export:%ENTRYPOINT% /LIBPATH:"C:\Program Files\MATLAB\R2024a\extern\lib\win64\microsoft"
        set LINKDEBUGFLAGS=/debug /PDB:"%OUTDIR%%MEX_NAME%.exe.pdb"
        set NAME_OUTPUT=/out:"%OUTDIR%%MEX_NAME%%MEX_EXT%"
VCROOT : C:\Program Files\Microsoft Visual Studio\2022\Community
SDKROOT : C:\Program Files (x86)\Windows Kits\10\
VSINSTALLDIR : C:\Program Files\Microsoft Visual Studio\2022\Community
VCINSTALLDIR : C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808
VCVARSALLDIR : C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Auxiliary\Build
KITSROOT : C:\Program Files (x86)\Windows Kits\10\
SDKVERSION : 10.0.22621.0
MATLABROOT : C:\Program Files\MATLAB\R2024a
ARCH : win64
SRC : "C:\Users\marke\OneDrive\Skola\vyuka2024-2025\LS\PVM\cvičeni11\engwindemo.c"
OBJ : C:\Users\marke\AppData\Local\Temp\mex_75247487041762_3344\engwindemo.obj
OBJS : C:\Users\marke\AppData\Local\Temp\mex_75247487041762_3344\engwindemo.obj
SRCROOT : C:\Users\marke\OneDrive\Skola\vyuka2024-2025\LS\PVM\cvičeni11\engwindemo
DEF : C:\Users\marke\AppData\Local\Temp\mex_75247487041762_3344\engwindemo.def
EXP : "engwindemo.exp"
LIB : "engwindemo.lib"
EXE : engwindemo.exe
ILK : "engwindemo.ilc"
TEMPNAME : engwindemo
EXEDIR :
EXENAME : engwindemo
MANIFEST : "engwindemo.exe.manifest"
OPTIM : /O2 /Oy- /DNDEBUG
LINKOPTIM :

```

```

-----
Building with 'Microsoft Visual C++ 2022 (C)'.
cl /c /Zc:__cplusplus /Zp8 /GR /W3 /EHs /nologo /MD /O2 /Oy- /DNDEBUG /DMATLAB_DEFAULT_RELEASE=R2024a /DUSE_MEX_CMD
engwindemo.c

```

```

link /nologo C:\Users\marke\AppData\Local\Temp\mex_75247487041762_3344\engwindemo.obj /LIBPATH:"C:\Program Files\Microsoft Visual Studio\2022\Community\VC\Tools\MSVC\14.43.34808\x-
if exist "engwindemo.ilc" del "engwindemo.ilc"
MEX completed successfully.

```

Podívejte se na zdrojový kód (engwindemo.c), jak vypadá kód odkazující se na Matlab funkce.

Python

```
import matlab.engine
eng = matlab.engine.start_matlab()
result = eng.sqrt(16.0)
print(result)
```

Volání knihoven v jiných jazycích

Vlastní funkce, jako Matlabové

C

MEX soubory - nízkoúrovňové programování

Matlab je dostatečně optimalizovaný, že nejsou potřeba

V C napíšeme kód a také funkci, která bude zajišťovat komunikaci:

```
void mexFunction(int nlhs, mxArray *plhs[], int nrhs, const mxArray *prhs[])
```

nlhs - počet výstupních argumentů

plhs - pole výstupních argumentů

nrhs - počet vstupních argumentů

prhs - pole výstupních argumentů

Podívejte se na kód arrayProduct.c

Překlad funce - vytvoření .mex

```
mex arrayProduct.c
```

```
Building with 'Microsoft Visual C++ 2022 (C)'.
MEX completed successfully.
```

Volání

```
s = 5;
A = [1.5, 2, 9];
B = arrayProduct(s,A)
```

```
B = 1×3
    7.5000    10.0000    45.0000
```

Konstrukce jiných jazyků v Matlabu

Je možné načíst knihovny jiných jazyků a používat funkce v nich definované.

C

načtení knihovny: `loadlibrary('shrlib','hfile')`

Načteme příklad:

```
addpath(fullfile(matlabroot,'extern','examples','shrlib'))
if not(libisloaded('shrlibsample'))
    loadlibrary('shrlibsample')
end
```

Výpis funkcí z knihovny `libfunctions()`

```
libfunctions('shrlibsample')
```

Functions in library shrlibsample:

`addDoubleRef`

`addMixedTypes`

`addStructByRef`

`addStructFields`

`allocateStr`

Volání funkcí `calllib()`

```
str = 'Volani funkce z knihovny.';
calllib('shrlibsample','stringToUpper',str)
```

```
ans =
'VOLANI FUNKCE Z KNIHOVNY.'
```

Úklid po skončení práce s knihovnou

```
unloadlibrary shrlibsample
```

Python

`py.` prefix před python funkce

```
seznam = py.list({"Ahoj "," "})
```

```
seznam =
Python list with values:
```

```
['Ahoj ', ' ']
```

Use string, double or cell function to convert to a MATLAB array.

```
seznam.append("svete")
```

```
seznam
```

```
seznam =
Python list with values:
```

```
['Ahoj ', ' ', 'svete']
```

Use string, double or cell function to convert to a MATLAB array.

```
seznam{1}
```

```
ans =  
Python str with no properties.  
  
Ahoj
```

```
string(cell(seznam))
```

```
ans = 1x3 string  
"Ahoj " " " "svete"
```

```
a = 90;  
pyvysledek = py.math.radians(a)
```

```
pyvysledek = 1.5708
```

```
py.print("Ahoj")
```

```
Ahoj
```

Od verze R2021b je možné volat rovnou python kód v Matlabu pomocí funkce

```
pyrun(code)
```

```
pyrunfile(file)
```

```
pyrun(["pozdrav = 'Nazdarek'", "print(pozdrav)"])
```

```
Nazdarek
```

```
pyrunfile("ahoj.py")
```

```
Zdravicko
```

Java

Matlab pracuje s java objekty

Je možné importovat třídy, vytvářet objekty, volat metody

```
jDate = java.util.Date()
```

.NET (pouze Windows)

```
asm = NET.addAssembly('System.Windows.Forms');  
form = System.Windows.Forms.Form();  
form.Text = 'Hello';  
form.ShowDialog();
```

RestAPI

```
data = webread('https://api.exchangerate-api.com/v4/latest/USD')
```

Převod matlab kódu do jazyka C/C++

je potřeba mít Matlab Coder

```
codegen -config:lib -lang:c++ mujSoucet -args {0,0}
```

pomocí `-args` specifikujeme typ vstupních argumentů

Zabalení programů jako komponenty

je potřeba mít Matlab compiler

HTML

vkládání html do aplikace (htmlapp)

https://www.mathworks.com/help/matlab/creating_guis/create-an-html-file-that-sets-data-or-responds-to-data-changes-from-matlab.html

Web s matlabem

<https://www.mathworks.com/videos/how-to-build-a-web-site-powered-by-matlab-106529.html>

Export live skriptu do HTML

Generování části stránky matlabem