## Calling C from Matlab: Introduction

- Matlab functions written in C++ are called MEX-files.
- MEX stands for Matlab EXectuable.
- MEX-files are dynamically linked subroutines produced from C/C++ or Fortran code.
- On windows these files have the extension .dll.
- Main reasons to write a MEX-file are:
  1. To use pre-existing C/C++ or Fortran routines in Matlab without having to recode them.
  2. Increase speed: most effective on loops.

## The mxArray

All Matlab variables are stored as Matlab arrays. In C, the Matlab array is declared to be of type `mxArray`, which is defined by a structure.

The structure contains:

- Its type.
- Its dimensions.
- The data associated with the array.
- If numeric, whether real or complex.
- If sparse, its nonzero indices.
- If a structure or object, more info.

## Matlab Types

- Fundamental types:
  `double, char, logical, uint8, cell, struct`
- Derived Types (represented in C by the mxArray structure):
  - Numeric
    - Complex double-precision nonsparse matrix.
      - Complex.
      - Real (pointer to vector of imaginary elements points to NULL).
    - Single-precision floating point, 8-,16-, and 32-bit integers, both signed and unsigned, real and complex.
  - Strings (strings are not null terminated as in C).
  - Sparse Matrices, Cell Arrays, Structures, Objects, Multidimensional Arrays.

## Components of MEX Files

A MEX-file consists of two distinct parts:

- A computational routine: code that does what function is supposed to do.
- A gateway routine: code that interfaces the computational routine with MATLAB.

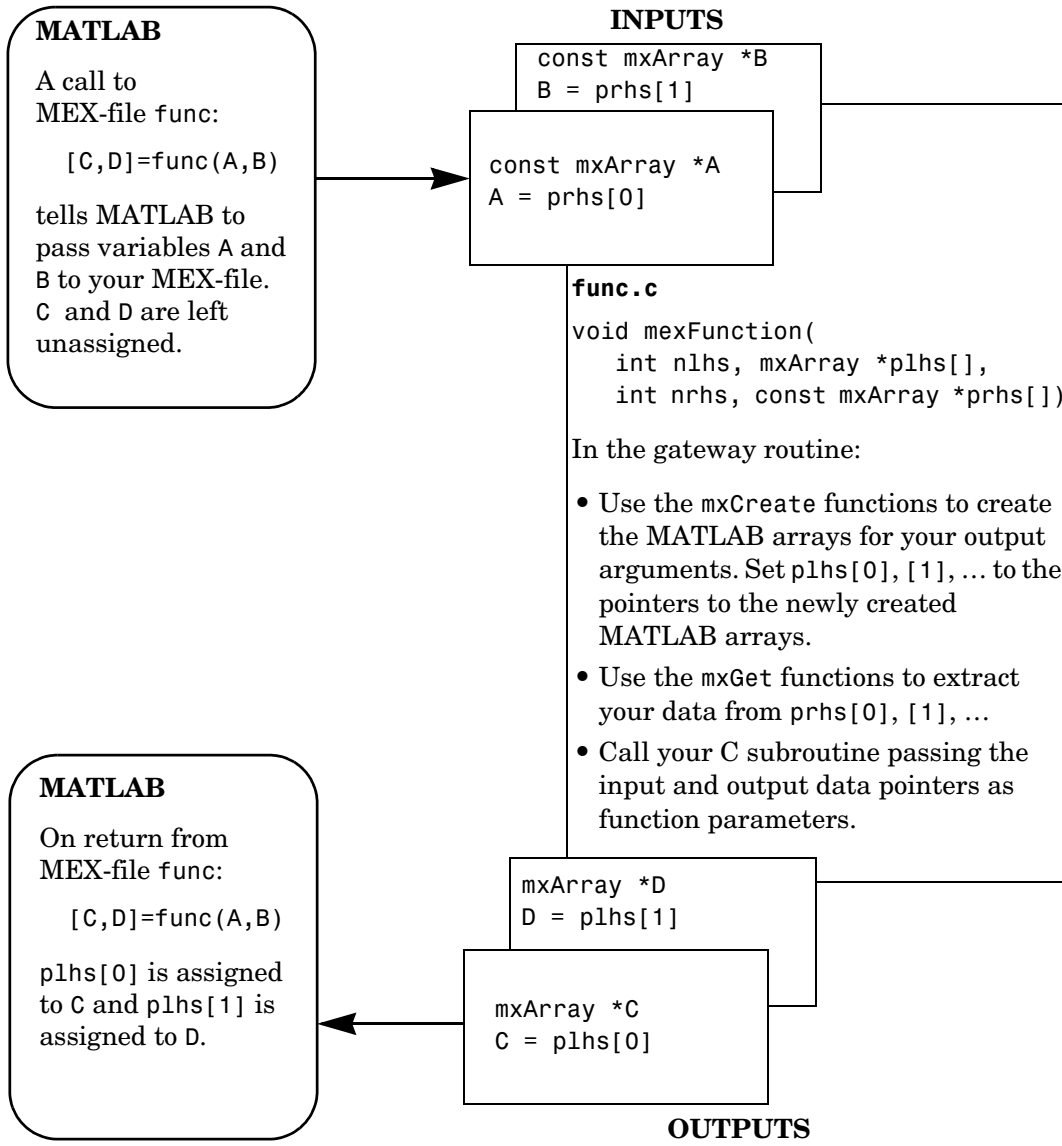


**Figure 4-1: C MEX Cycle**

## The mexFunction: Gateway to Matlab

- The main() function is replaced with mexFunction.

```
#include "mex.h"
void mexFunction(int nlhs, mxArray *plhs[], int nrhs, const mxArray
*prhs[]) {  //code that handles interface and calls
                        //to computational function
                        return; }
```

- mexFunction arguements:
  - `nlhs`: The number of lhs (output) arguments.
  - `plhs`: Pointer to an array which will hold the output data, each element is type `mxArray`.
  - `nrhs`: The number of rhs (input) arguments.
  - `prhs`: Pointer to an array which holds the input data, each element is type const `mxArray`.

## MX Functions

The collection of functions used to manipulate mxArrays are called MX-functions and their names begin with `mx`.

Examples:

- mxArray creation functions:
  `mxCreateNumericArray`, `mxCreateDoubleMatrix`, `mxCreateString`, `mxCreateDoubleScalar`.
- Access data members of mxArrays:
  `mxGetPr`, `mxGetPi`, `mxGetM`, `mxGetN`.
- Modify data members:
  `mxSetPr`, `mxSetPi`.
- Manage mxArray memory:
  `mxMalloc`, `mxCalloc`, `mxFree`, `mxDestroyArray`.

## MEX Functions

The collection of functions used to perform operations back in Matlab are called MEX-functions and begin with `mex`.

Examples:

- `mexFunction`: Gateway to C.
- `mexEvalString`: Execute Matlab command.
- `mexCallMatlab`: Call Matlab function(.m or .dll) or script.
- `mexPrintf`: Print to the Matlab editor.
- `mexErrMsgTxt`: Issue error message and exit returning control to Matlab.
- `mexWarnMsgTxt`: Issue warning message.

## More Information

Go to mathworks website. In the matlab support section look at:

- External Interfaces
  -good for concepts and compiling/linking/debugging issues.
- External Interfaces Reference
  -good for looking up mx- and mex- funtions.