Determination of matrices of a manipulator geometrical model with use of symbolic operation

Symbolic matrices

It is recommended to apply functions of the 'modelgeo' library prepared for use in Matlab. Below there is presented an example of evaluation of ${}^{0}\underline{T}_{3}$ matrix for a RRP kinematic structure.

```
% this script determines a Homogeneous Transformation HT matrix
clear all
% declaration of symbols
syms th1 a1 th2 a2 a3 q1 q2
% determination of a symbolic form of HT matrices -
% application of mA function
A1=mA(th1,0,a1,0)
A2=mA(th2,0,a2,0)
A3=mA(0,0,a3,sym(pi/2))
% multiplication of matrices
T03=A1*A2*A3
% substitution of rotational joint variables
% for the simplification purpose
T03v=subs(T03,{th1,th2},{q1,q2});
% indication of joint coordinates
% variables: th1,th2 and a3 indicated by '1's
zmie=[[1,0,0,0];[1,0,0,0];[0,0,1,0]]
% a simplified form of the evaluated HT matrices
% for interpretation purpose for a user
T03u=zam(zmie,T03v,'q')
```

Numerical matrices

In order to get numerical matrices, values of joint variables as well as values of constant parameters should be substituted to the symbolic matrices.

```
% example of substitution of the joint variables' values
% and constant values into the T0e matrix for the RRP manipulator example
% please use meters and radians
T03n=double(subs(T03,{th1,a1,th2,a2,a3},{pi/6,0.6,pi/4,0.4,0.4}))
```

Application Remarks.

First, the functions of the library should be downloaded, unpacked and saved to disk (at an accessible location).
To make the library available an appropriate path should be added to the list of paths in Matlab.

A list of functions to be used in the geometrical model formulation:

Function	***Call***	***Description***
mA	*mA(θ,a,d,α)*	*Determination of the homogeneous transformation matrix A* **Θ-** *angle of rotation around* **z** *axis* **d-** *displacement along* z *axis* **a-** *displacement along* x *axis* **α-** *angle of rotation around* x *axis*
zam	*zam(zmie,M,'q')*	*This procedure simplifies the form of a homogeneous transformation matrix M by substitution of S1 instead of sin(q1), S2 instead of sin(q2), C1 instead of cos(q1), S12 instead sin(q1+q2), C12 instead of cos(q1+q2) and S1_2 instead of sin(q1-q2) etc.* **zmie** *– is a matrix defining which parameter of the geometrical model is a variable (value 1) and which is constant (value of 0). Each row of the* zmie *matrix corresponds to one row of the homogeneous matrix M* **M** *– a matrix that is to be simplified*
subs	*subs(Y,OLD,NEW)*	*The procedure is intended for substitution of a symbol/number or a set of symbols/numbers (NEW) for another symbol or another set of symbols (OLD).* *A set of symbols/numbers is listed in brackets e.g. {q1,q2}* ***Y*** *– an expression in which the symbols are to be substituted for*