

The logo for MATLAB EXPO 2018 India features a blue star shape with a white outline, set against a background of hands holding a glowing blue cube. The text "MATLAB EXPO 2018" is written in white, bold, uppercase letters across the top of the star, and "India" is written in a smaller white font below it.

MATLAB EXPO 2018
India

Dynamic modelling of multi-physical domain system by bond graph approach and its control using flatness based controller with MATLAB Simulink

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Need of reliable modelling and simulation tool for multi domain physical system



Development of a mathematical model for Mobile robot using Bond graph technique

Development of Simulink environment for multi domain system



Design of the bond graph model of the Mobile robot using MATLAB Simulink

Controller design to achieve desired task for multi domain system



Design of a Flatness based controller to achieve desired trajectory

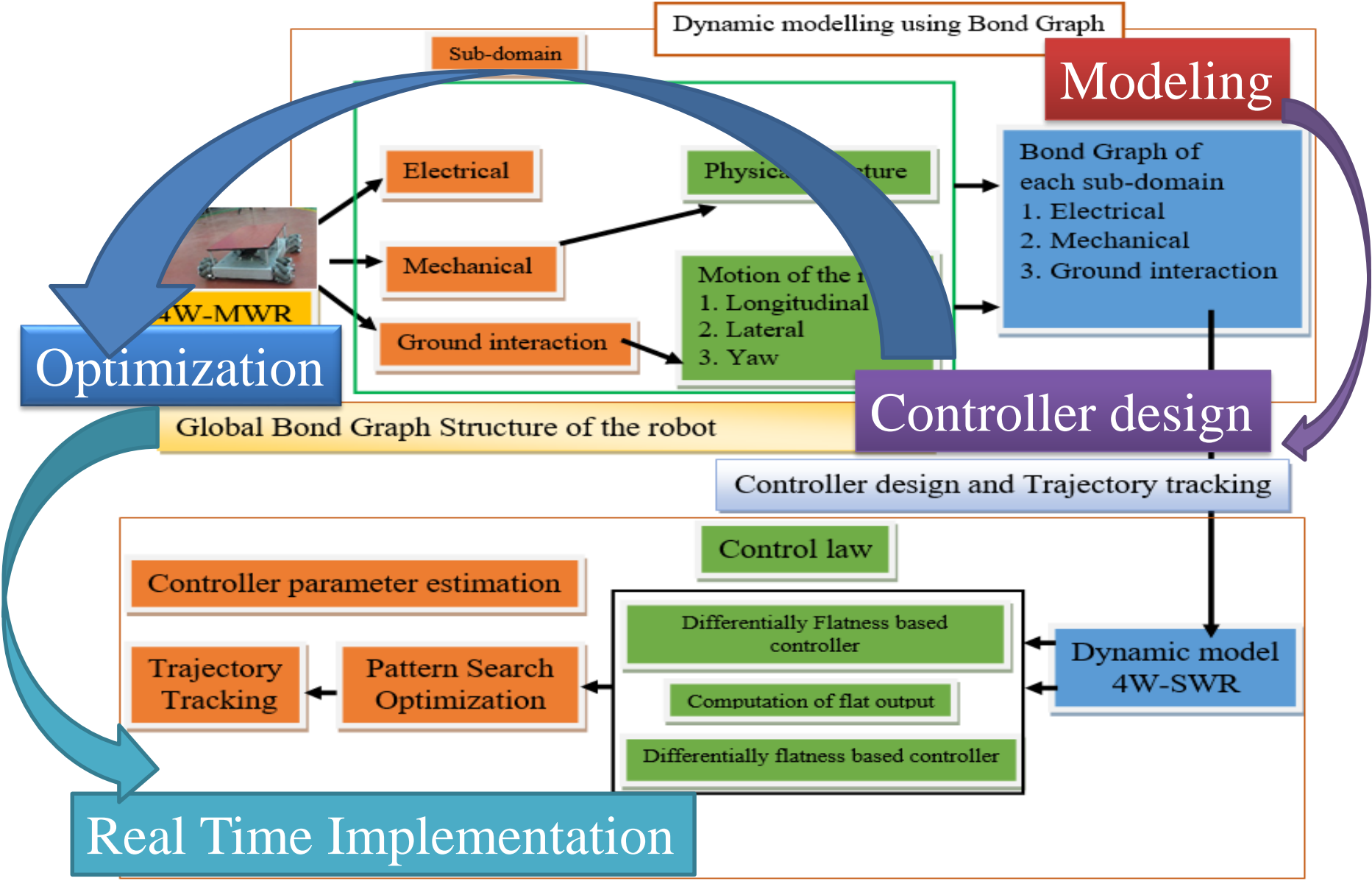
Real Time and hardware implementation



Real time implementation of the proposed Methodology using MATLAB hardware support package



Approach used to solve the problem



Modelling Challenges & Solutions With MATLAB/SIMULINK



Dynamic Modelling using Bond Graph

Non-Linear controller model

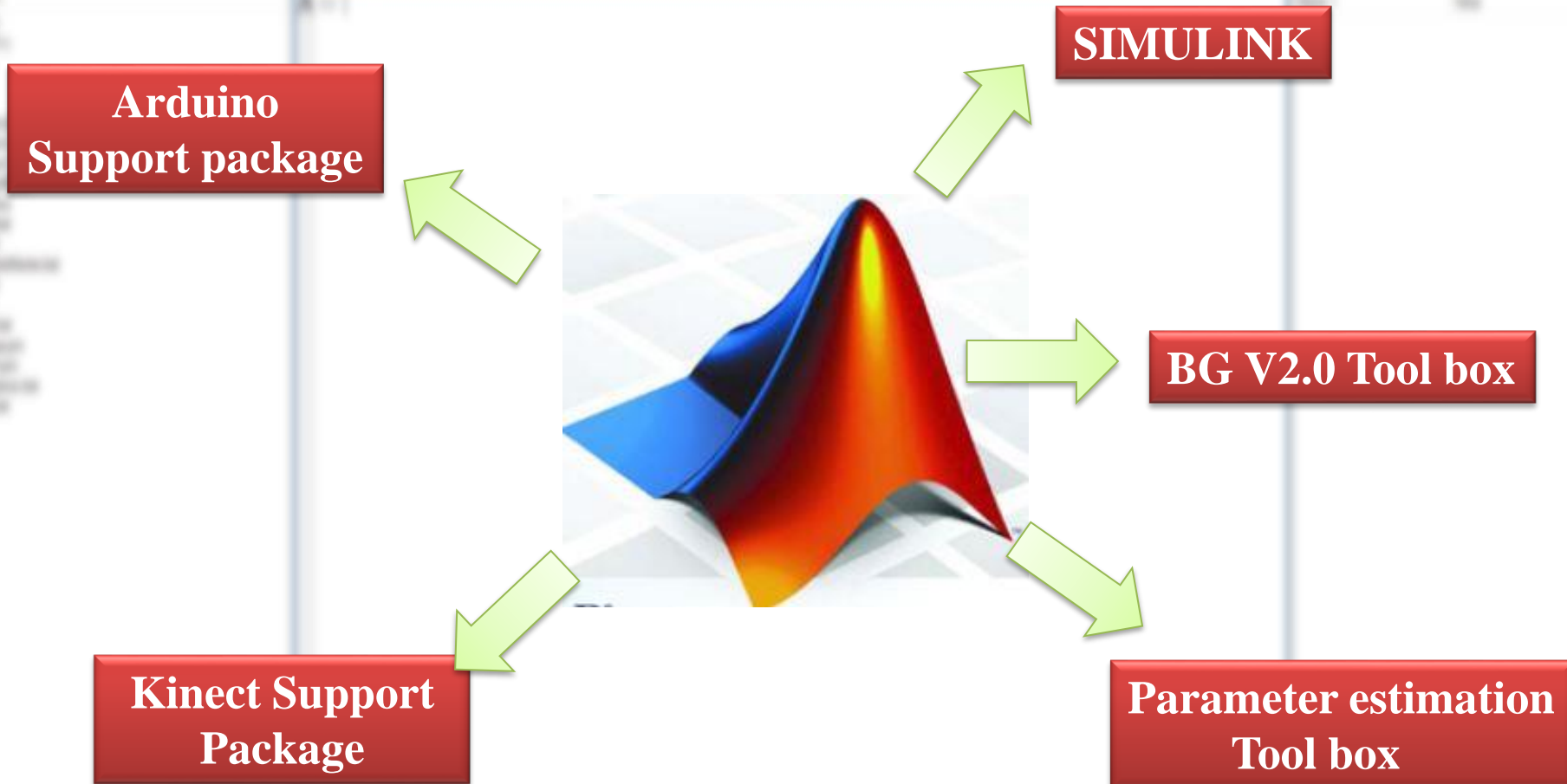
Solving Second order non linear Equations

Feedback data collection

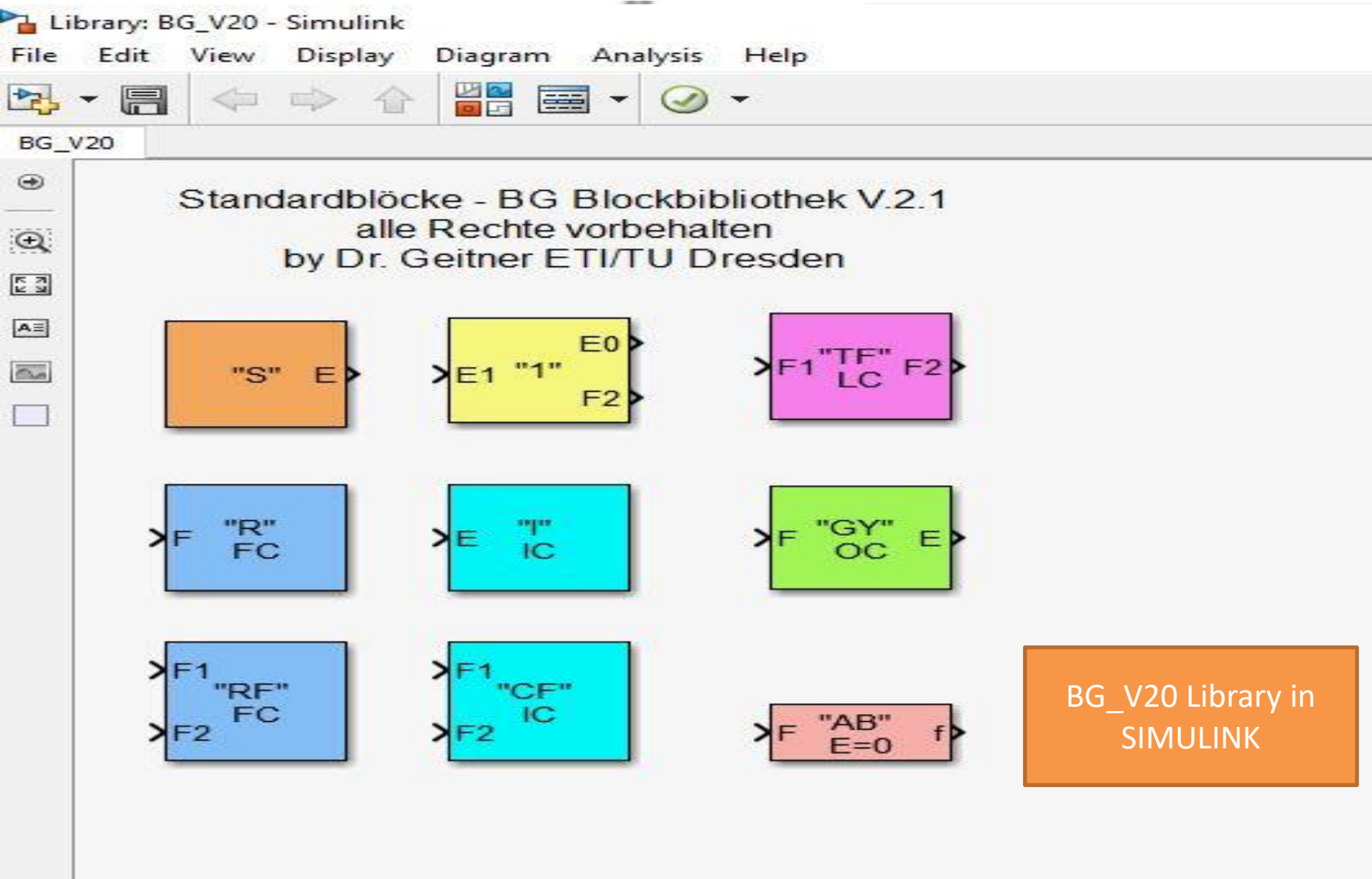
Real Time Hardware Implementation



Modelling Tool Used



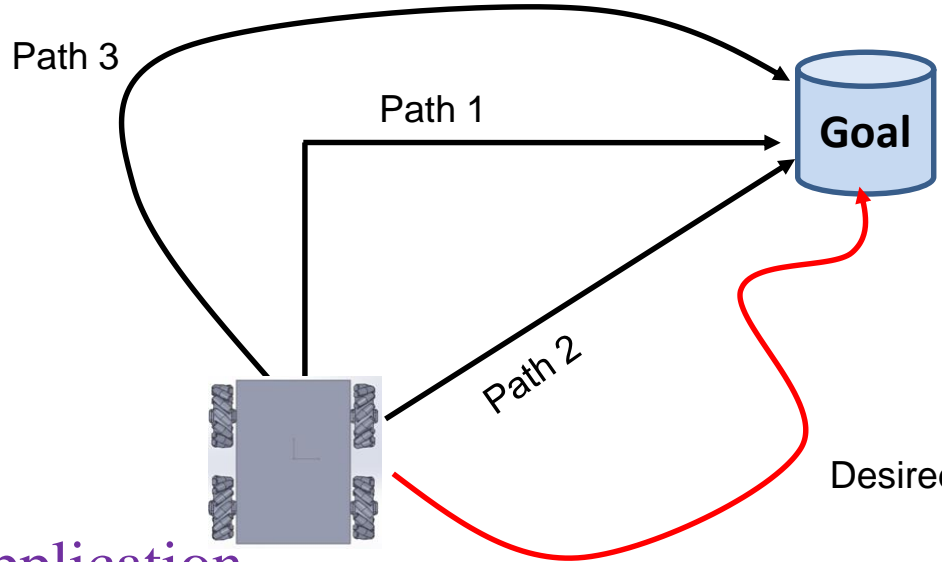
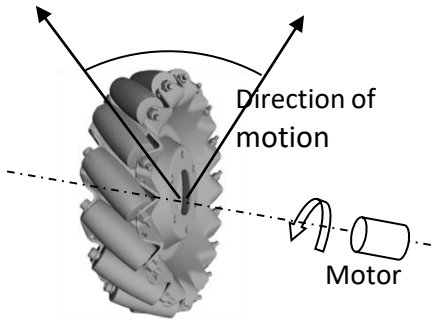
Bond Graph



BG_V20 Library in
SIMULINK



Four wheel omnidirectional mobile robot (FWOMR)



(FWOMR)

Application



Warehouse



Wheel chair



Omni move lifter



Home Purpose Robots

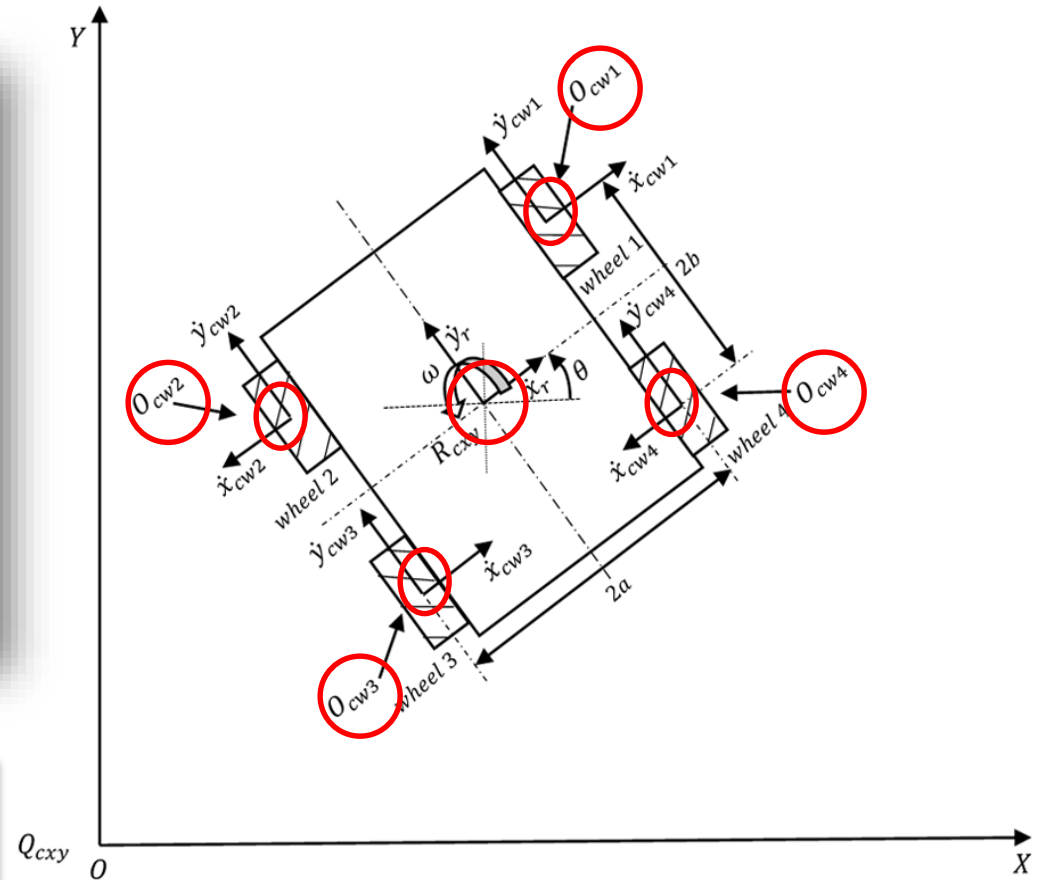


Kinematic modelling of the robot

$$\begin{bmatrix} \dot{x}_r \\ \dot{y}_r \\ \dot{\theta} \end{bmatrix} = J \begin{bmatrix} \dot{\theta}_{cw1} \\ \dot{\theta}_{cw2} \\ \dot{\theta}_{cw3} \\ \dot{\theta}_{cw4} \end{bmatrix}$$

where,

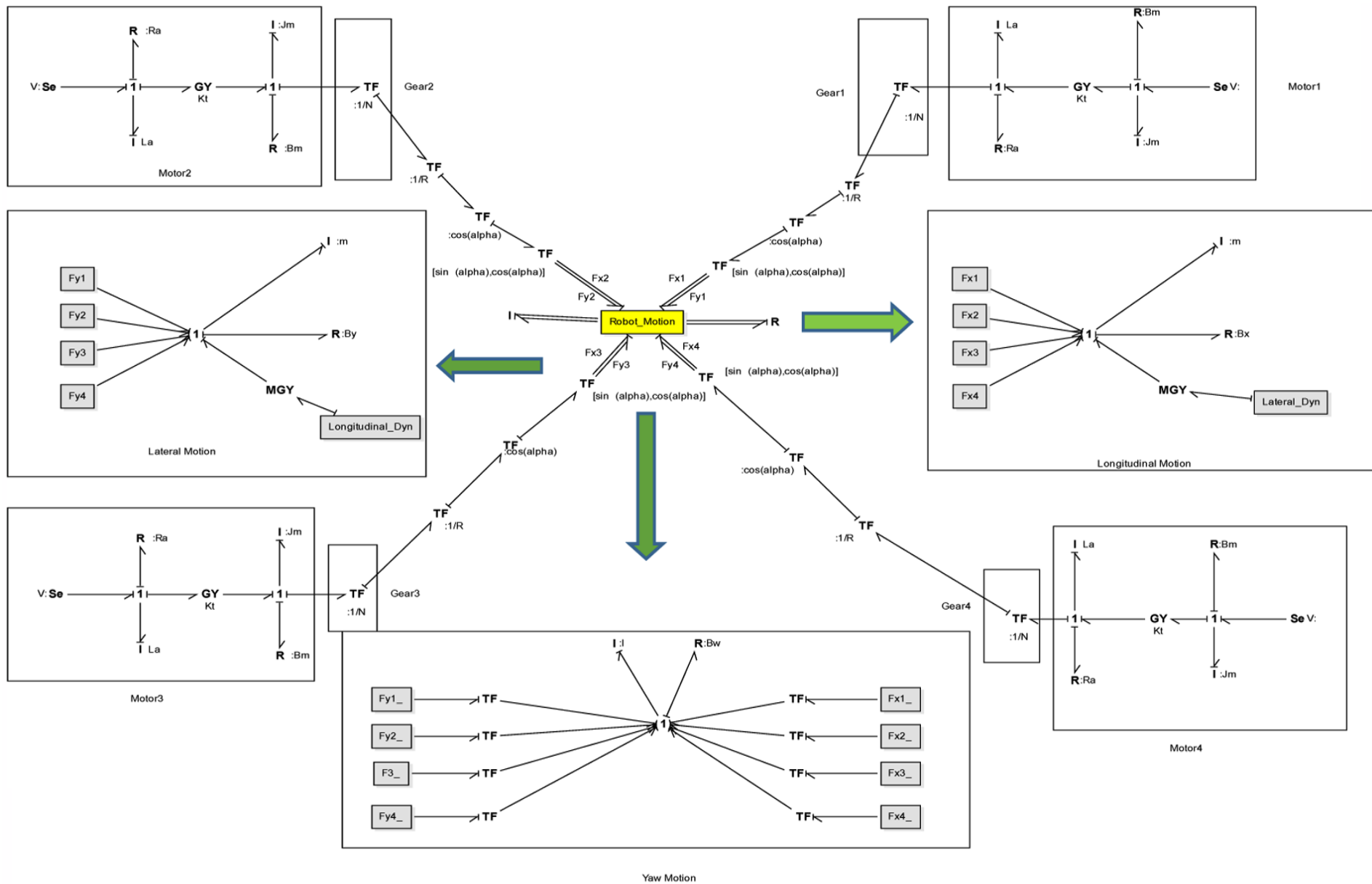
$$J = \frac{R}{4} \begin{bmatrix} -1 & 1 & -1 & 1 \\ 1 & 1 & 1 & 1 \\ \frac{1}{a+b} & -\frac{1}{a+b} & -\frac{1}{a+b} & \frac{1}{a+b} \end{bmatrix}$$



$$\begin{bmatrix} \dot{x}_q \\ \dot{y}_q \\ \dot{\theta}_q \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot{x}_r \\ \dot{y}_r \\ \dot{\theta}_r \end{bmatrix}$$



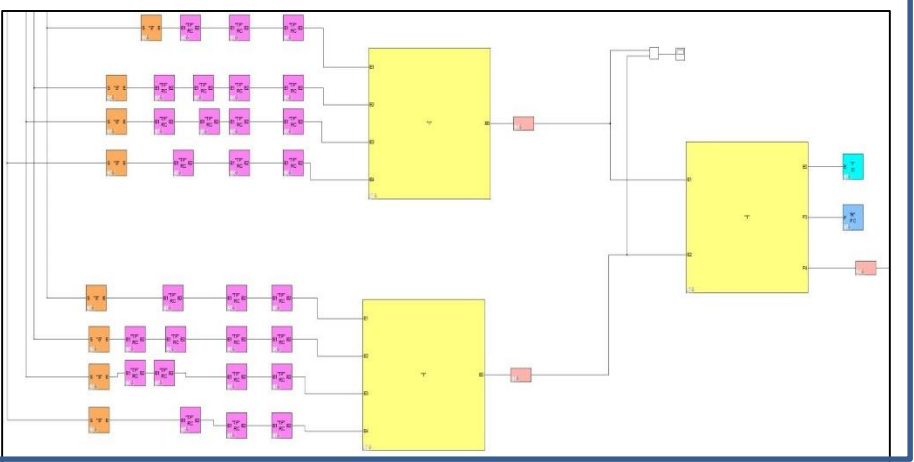
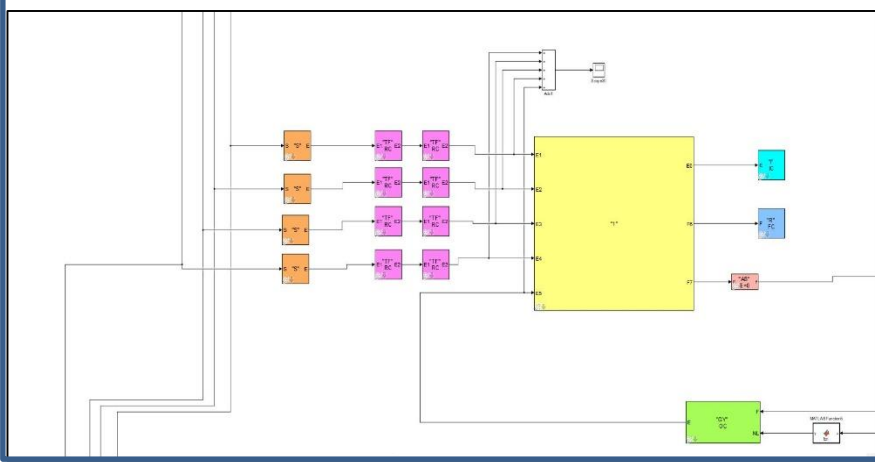
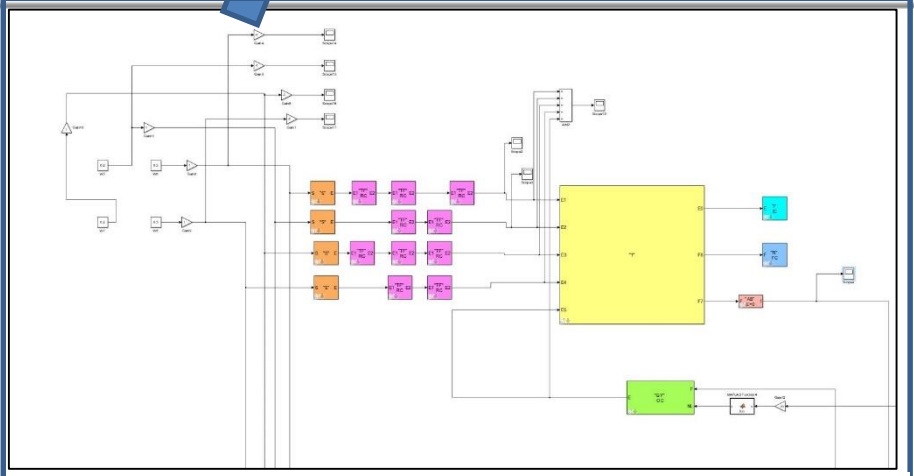
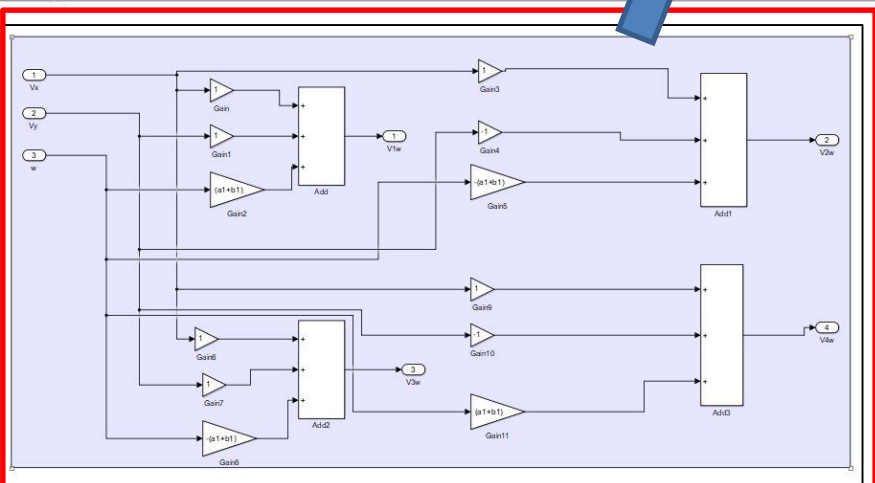
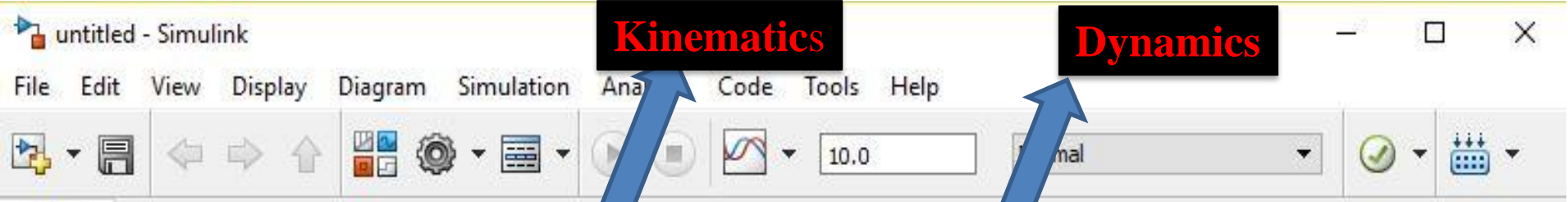
Dynamic modelling using Bond graph of the robot



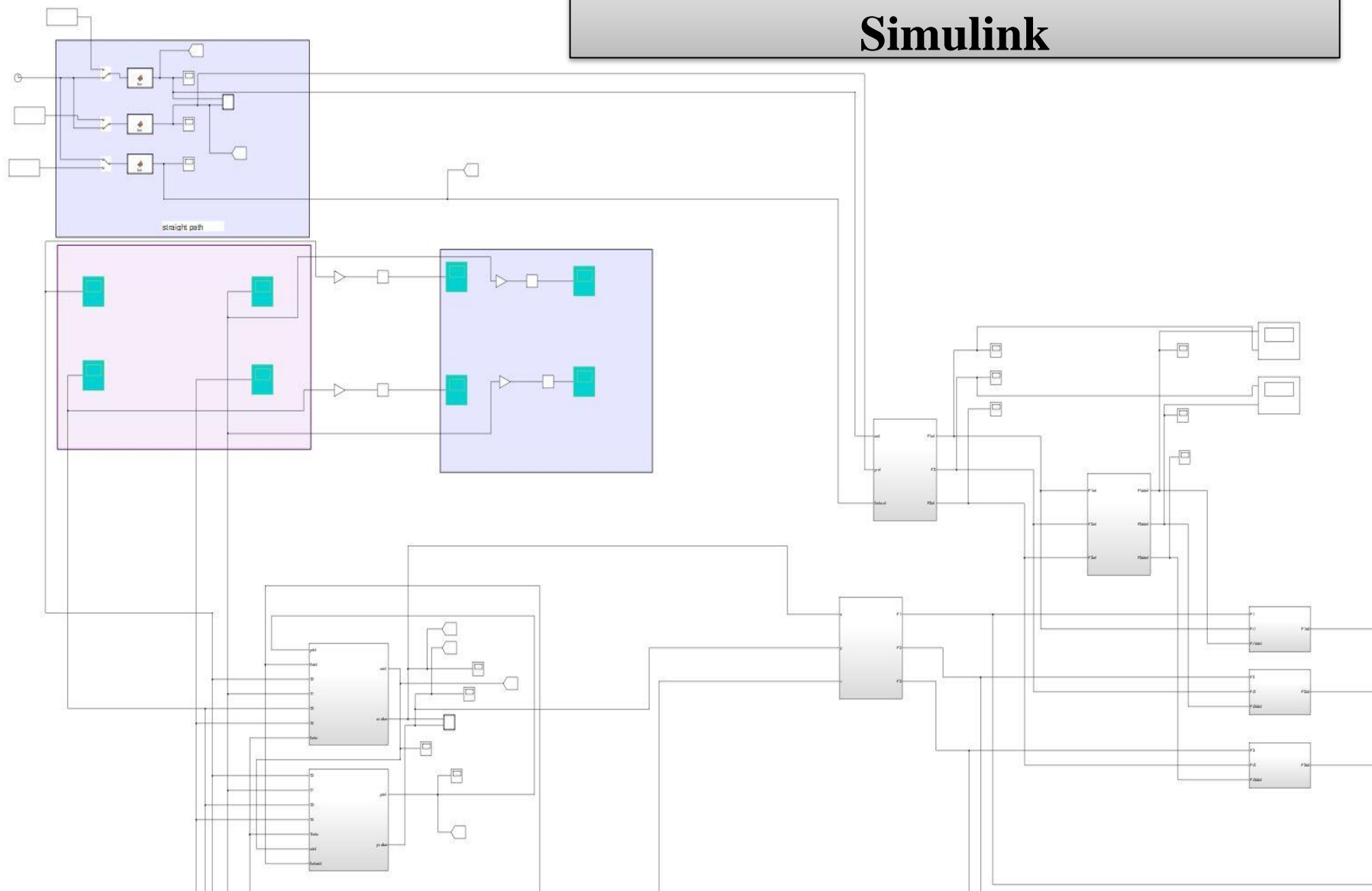
Kinematic and Dynamic Model Using Simulink

Kinematics

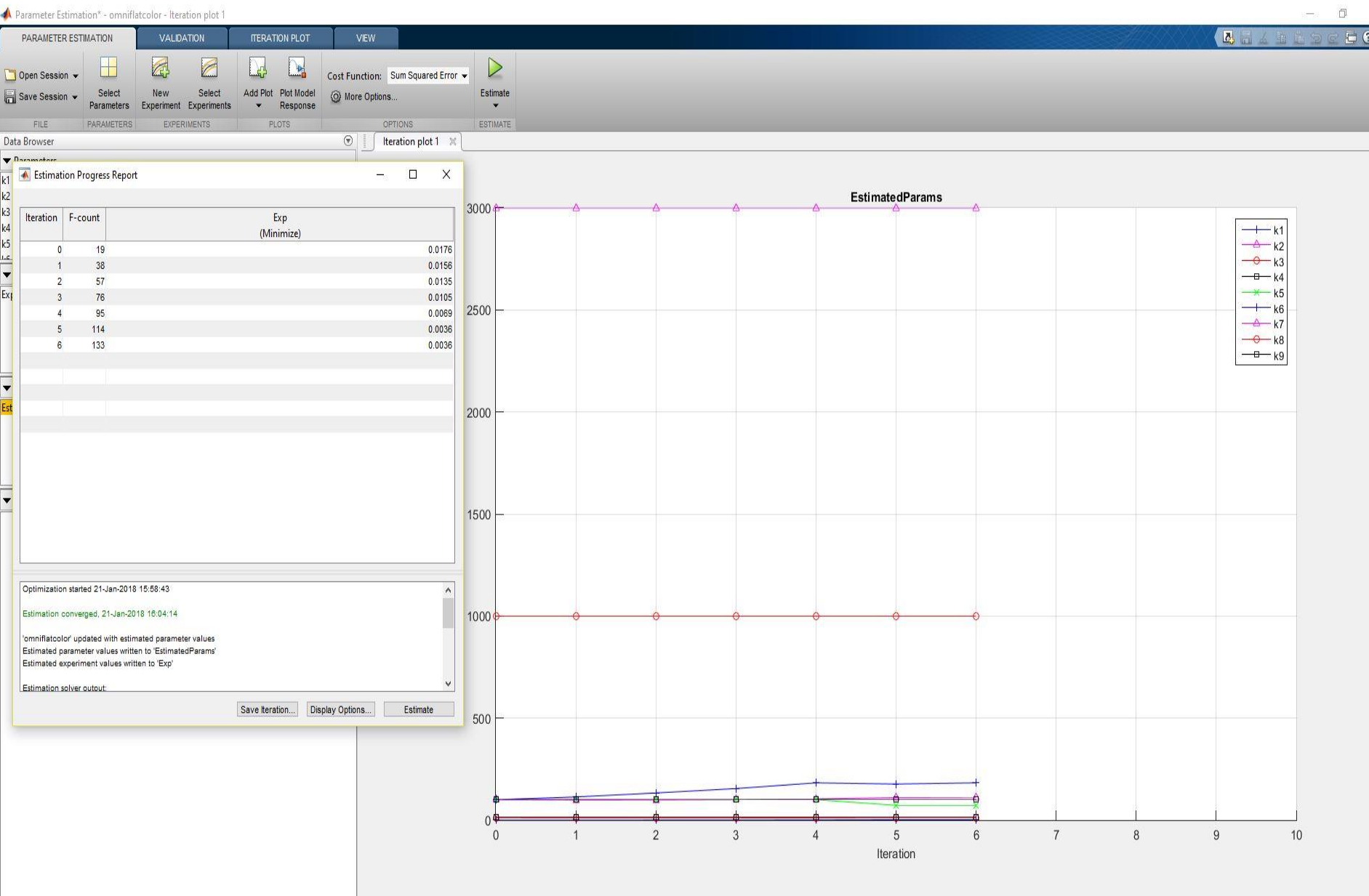
Dynamics



Flatness Based Controller in Simulink



Parameter Estimation toolbox For optimized controller parameter



Real Time Implementation of the proposed Scheme

The screenshot shows the MATLAB R2017a Add-On Explorer interface. The main window displays a list of add-ons with filters for type and hardware. The 'Hardware Support Packages' filter is selected. The 'Filter by Hardware Type' section shows 'Raspberry Pi' selected. The 'Filter by Vendor' section shows 'Arduino' selected. The main content area displays three add-ons: 'MATLAB Support Package for Raspberry Pi Hardware', 'Simulink Support Package for Raspberry Pi Hardware', and 'HC-SR04 Add-On Library for Arduino'. The 'MATLAB Support Package for Raspberry Pi Hardware' add-on is highlighted with a yellow circle.

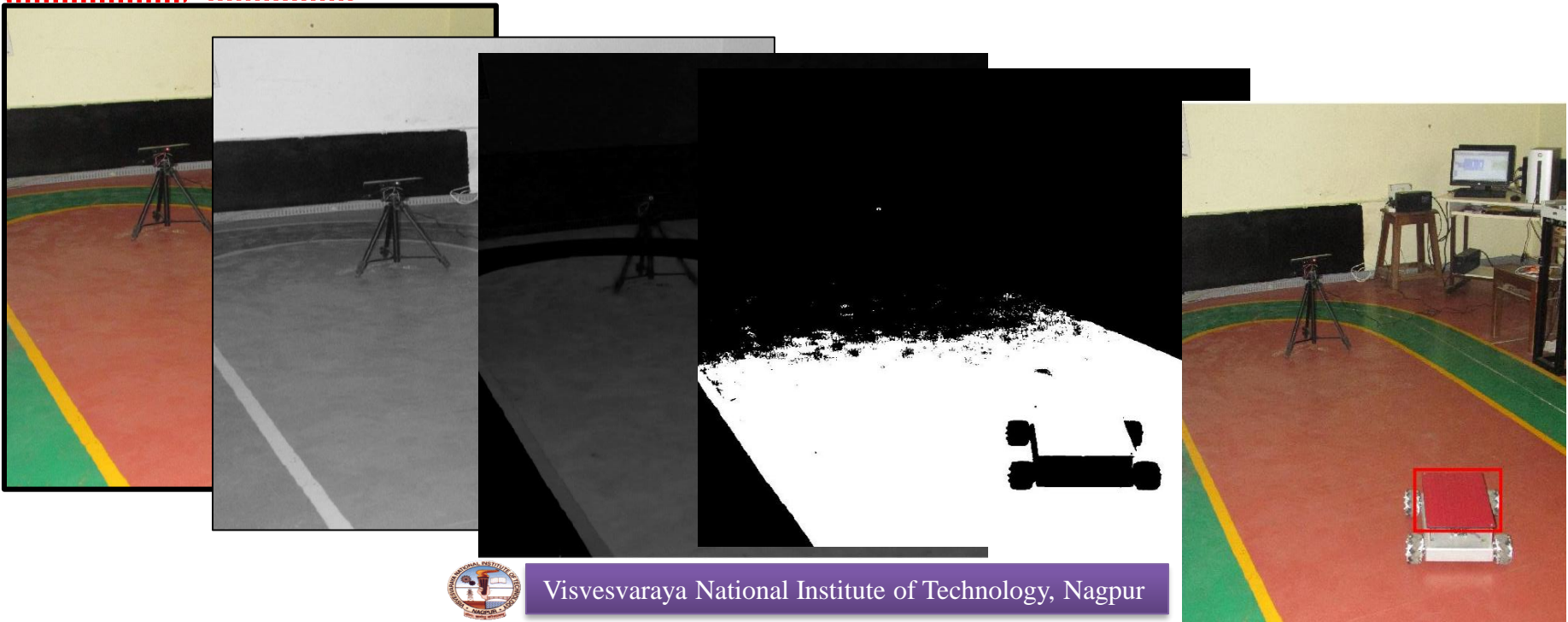
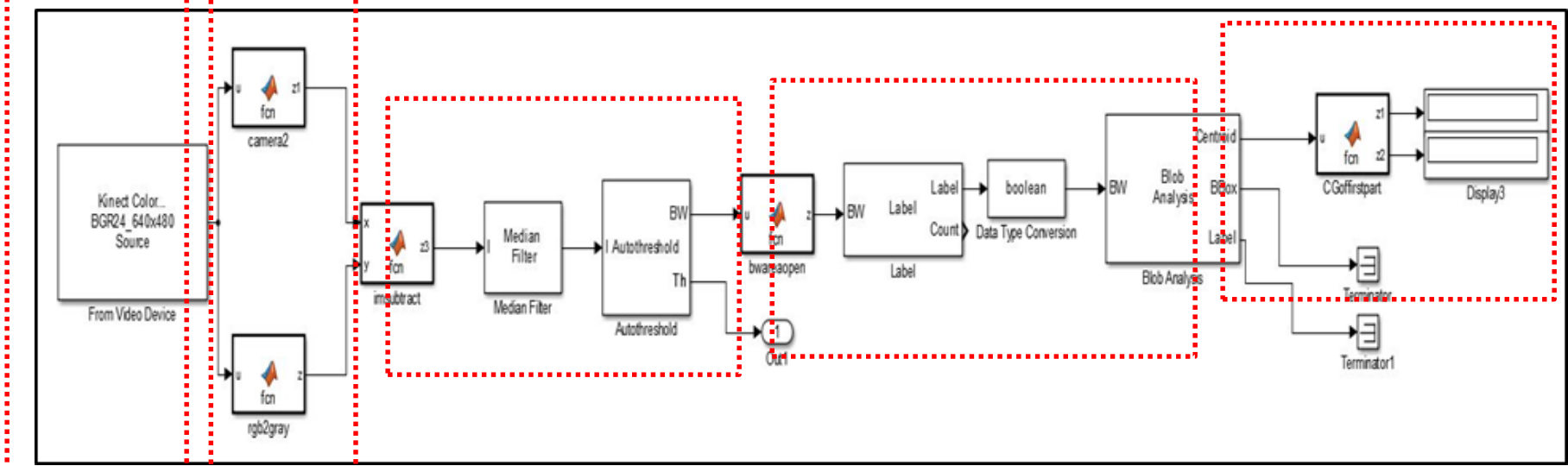
Filter Category	Item	Count
Filter by Type	Toolboxes and Products	8
	Simulink Models	25
	<input checked="" type="checkbox"/> Hardware Support Packages	36
	Functions	19
Filter by Hardware Type	Hobbyist/Maker	36
	<input checked="" type="checkbox"/> Raspberry Pi	9
Filter by Vendor	Android	2
	<input checked="" type="checkbox"/> Arduino	27
	ARM	15
	National Instruments	13
	Xilinx	7

Add-on Name	Downloads	Rating
MATLAB Support Package for Raspberry Pi Hardware	4010	4.5 stars
Simulink Support Package for Raspberry Pi Hardware	1857	4.5 stars
HC-SR04 Add-On Library for Arduino	1849	4.5 stars
MATLAB Support Package for Raspberry Pi Hardware	584	4.5 stars
Simulink Support Package for Raspberry Pi Hardware	522	4.5 stars
HC-SR04 Add-On Library for Arduino	298	4.5 stars

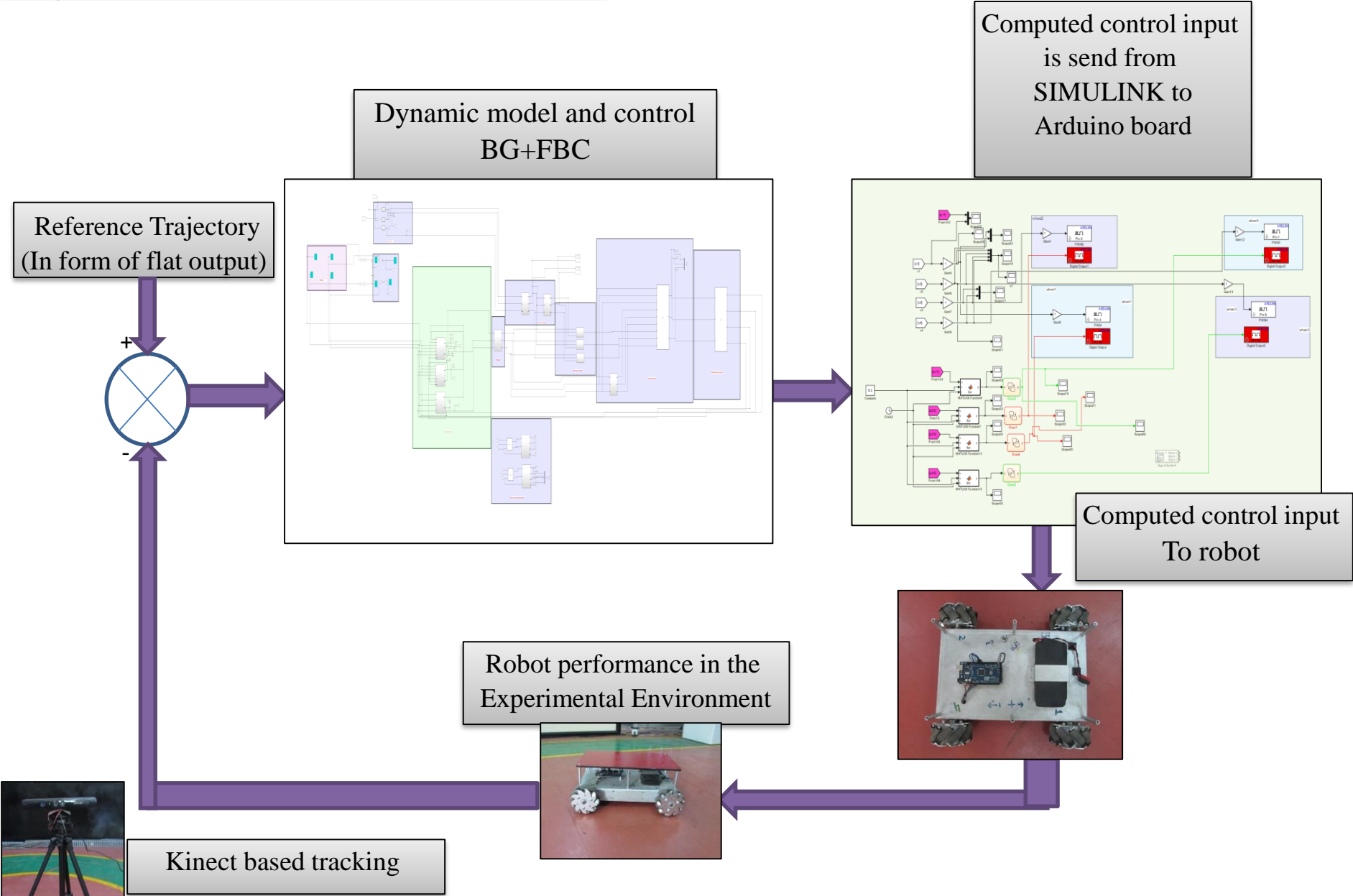


Real Time Implementation of the proposed Scheme

Feedback data collection using Kinect sensor



Experimental Environment



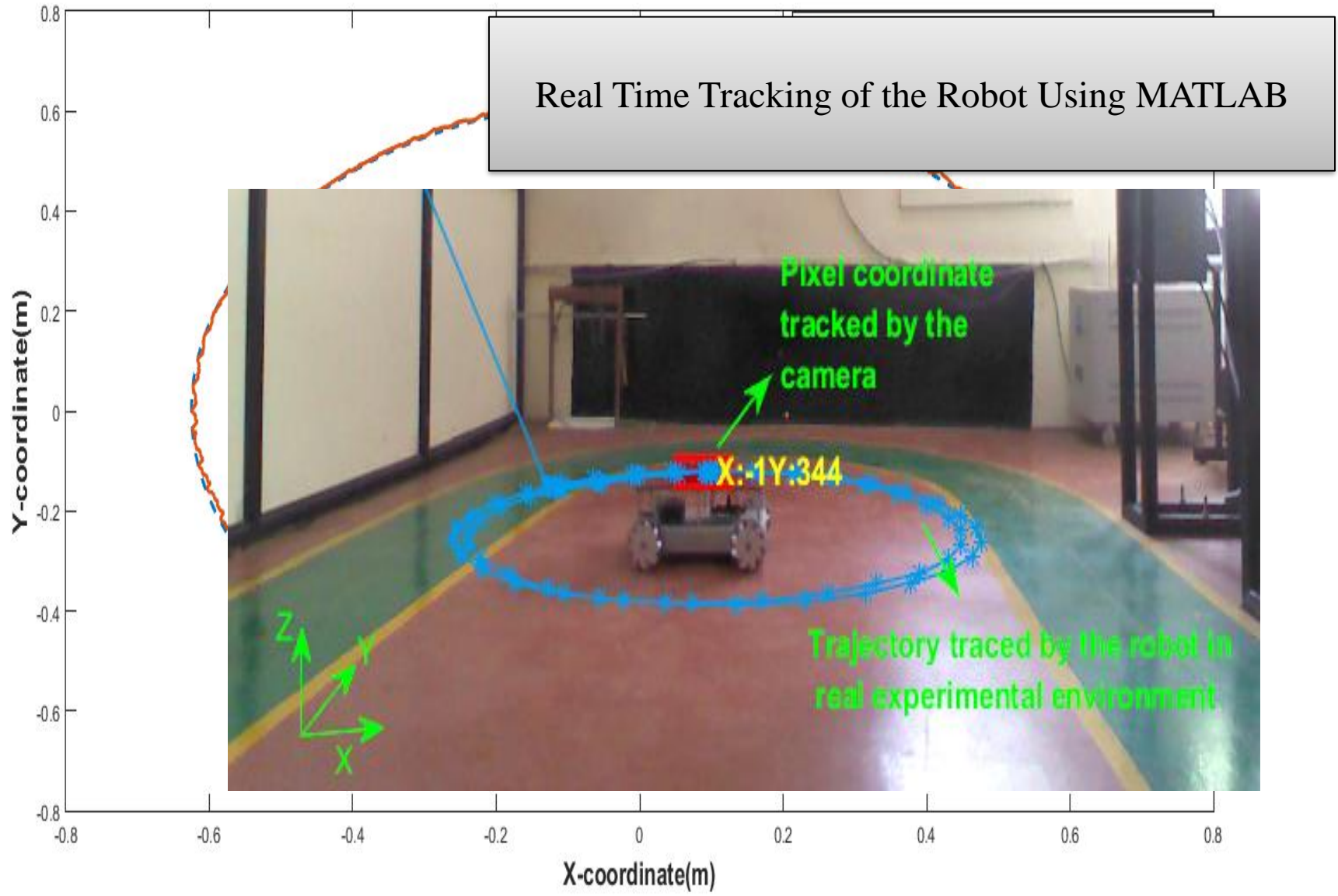
Robot performance in the Experimental Environment



Kinect based tracking



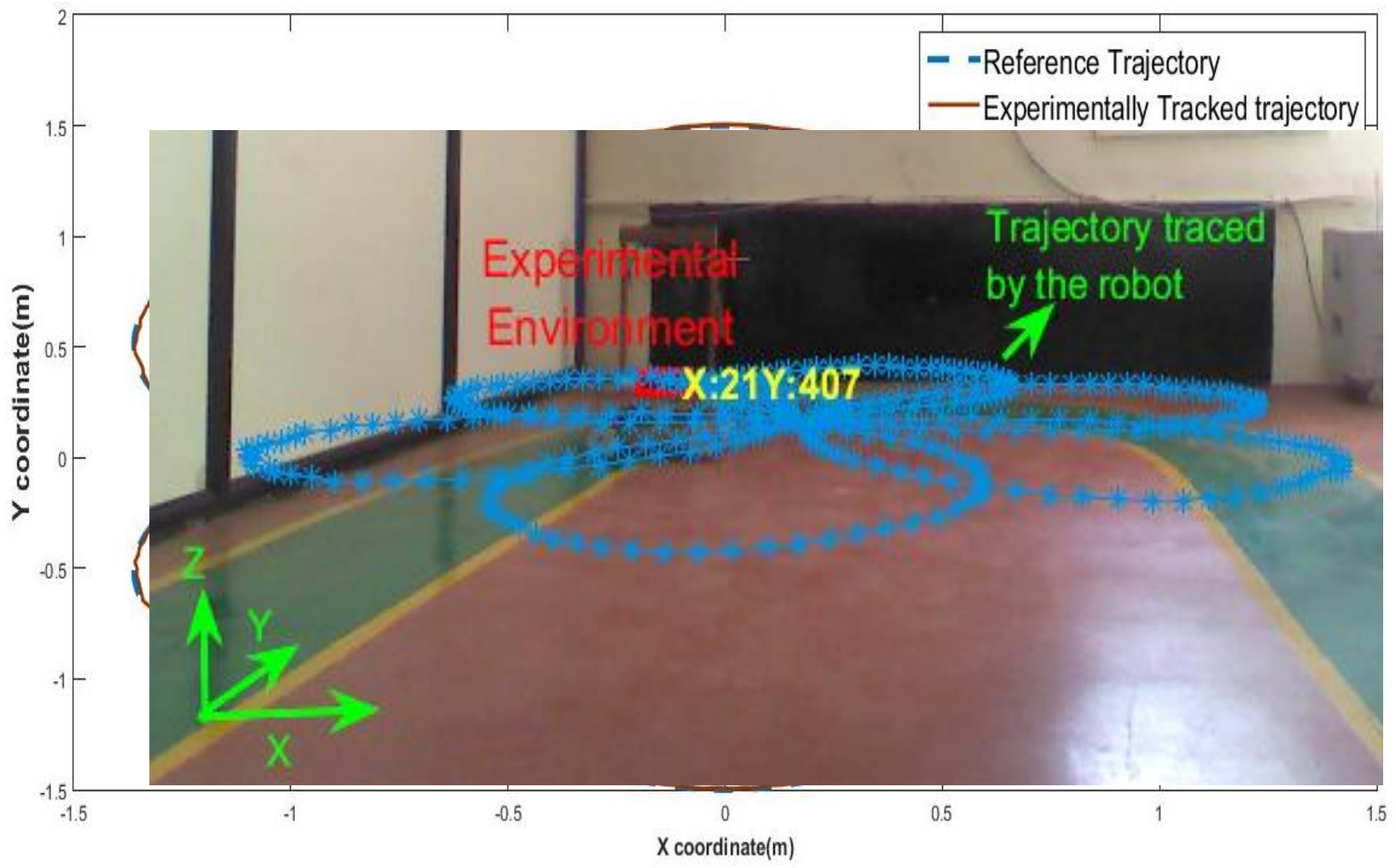
Result Achieved



Video



Result Achieved (More complicated trajectory)



Video



Conclusion

- ❖ Bond graph technique proved to be efficient to model complex Multi-physical systems. BGV_20 is found superior to other software like 20sim, CAMP-G etc.
- ❖ Flatness based controller essentially helps to linearize the system to get control law.
- ❖ Estimation of controller parameters using optimization tool box was efficiently done when used with simulation.
- ❖ Real time implementation of designed approach was successful due to hardware support packages.



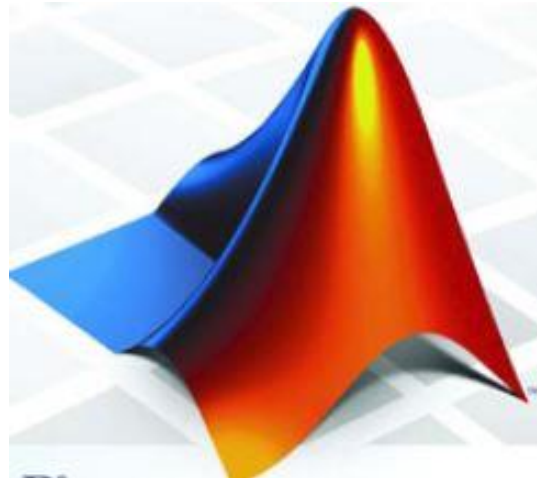
Why MATLAB ?

Provides all basic and advance tool for Scientific computation and research

Effective Tools for model based design of multi domain system

Implementation of control strategy using different blocks in SIMULINK

Real Time Implementation



Estimation of System Parameters

Wide range of Hardware support (like arduino, Kinect and others)

Ability to conduct number of simulations and experiments

