Zhifei Zhang

Summary of My Work during BS, MS, PhD (first year)

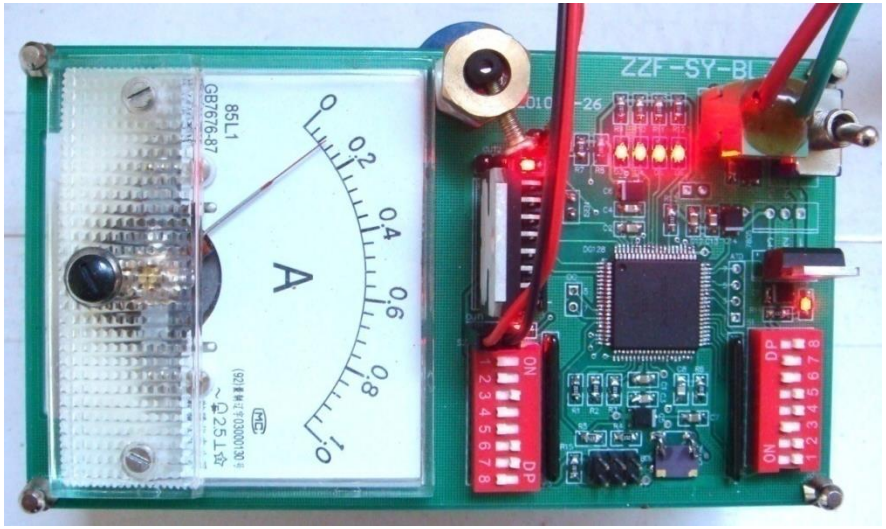
Key Words

- BS — Smart Car
- MS — Unmanned Helicopter
- PhD — Robotic hand

Smart Car

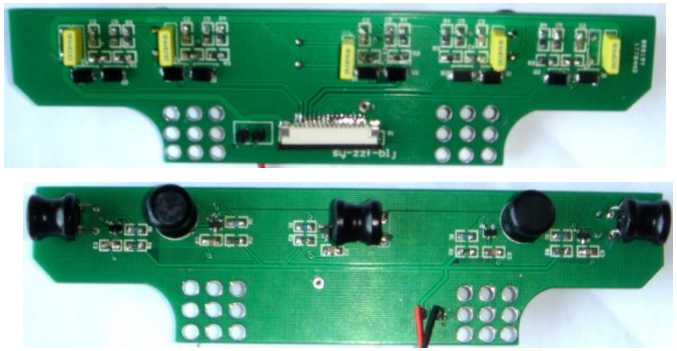
Task:

Design a car which can track a cable with alternative current (around 20KHz).

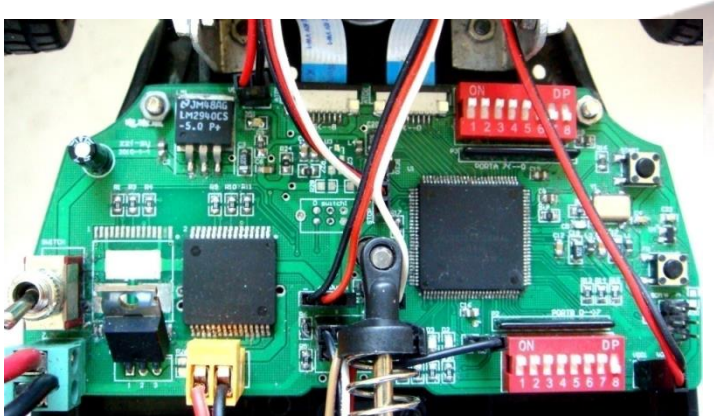


Signal generator

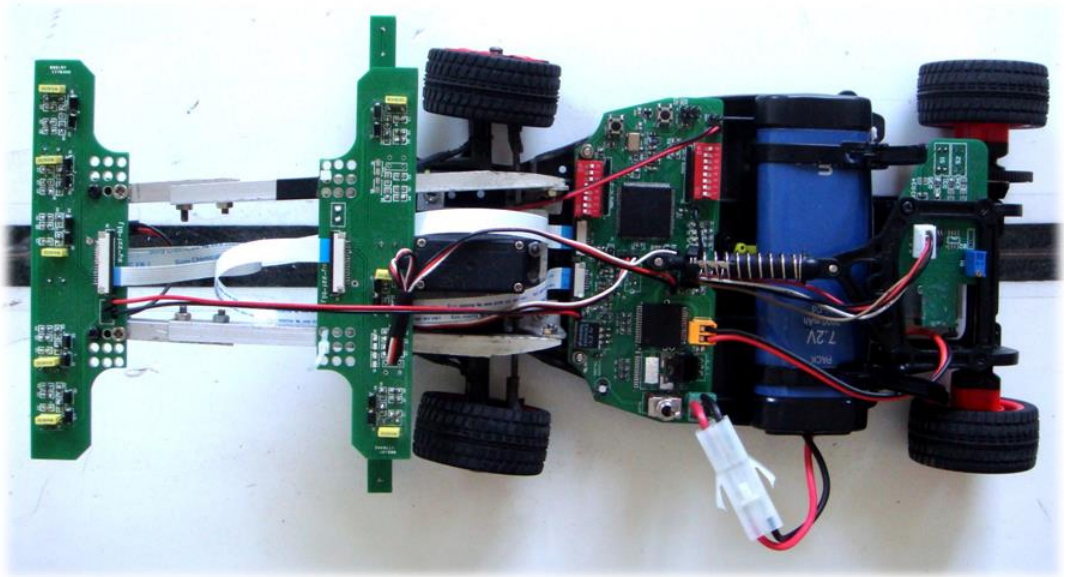
Smart Car



Magnetic sensor



Mother board

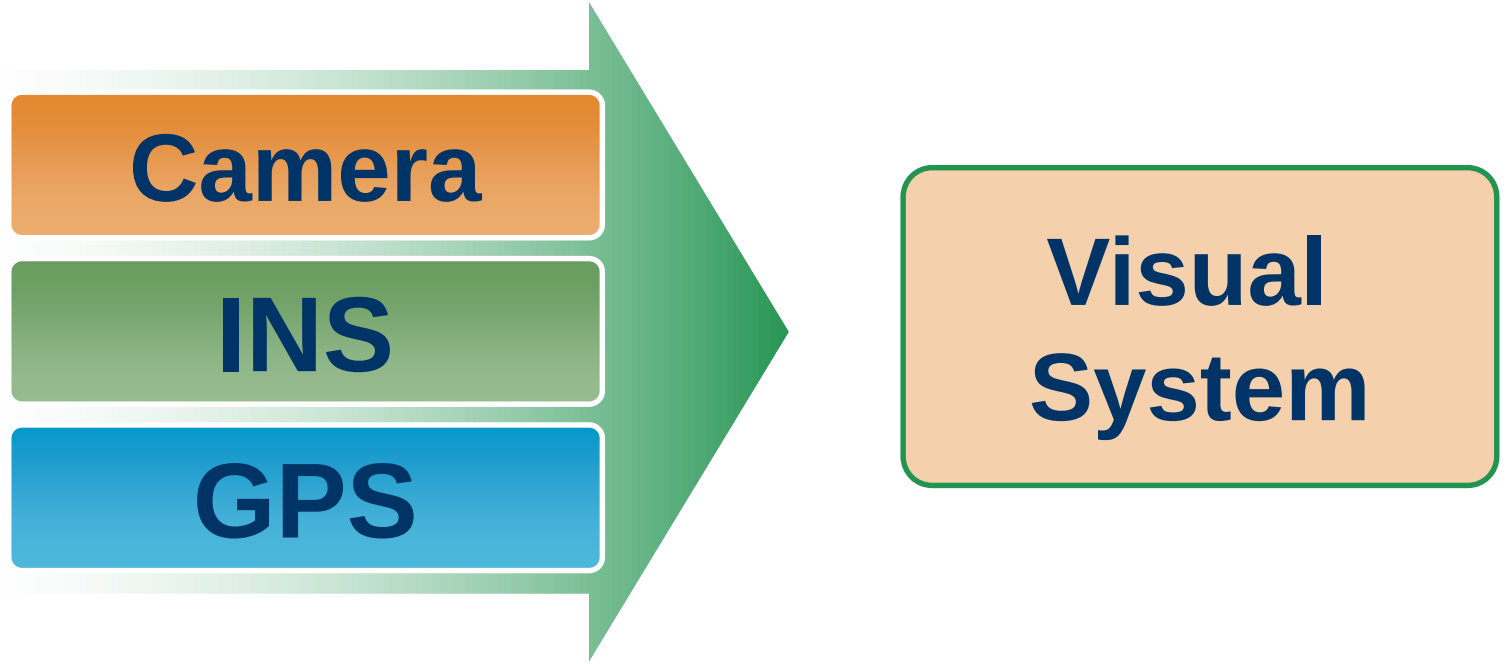


Smart Car

Unmanned Helicopter

Task:

Design a visual system for UAV to track and position ground target.



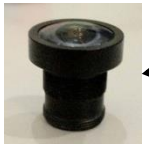
Unmanned Helicopter

Ground station

GPS

Wireless

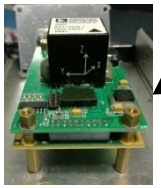
Fish eye Cam



Visual board

PC104 Control board

INS



Control box

SSD

Unmanned Helicopter

Calibration of fish eye camera:

Zhang algorithm + Brown model

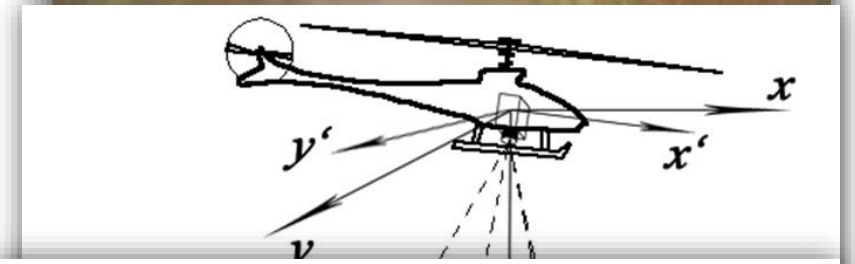
Before

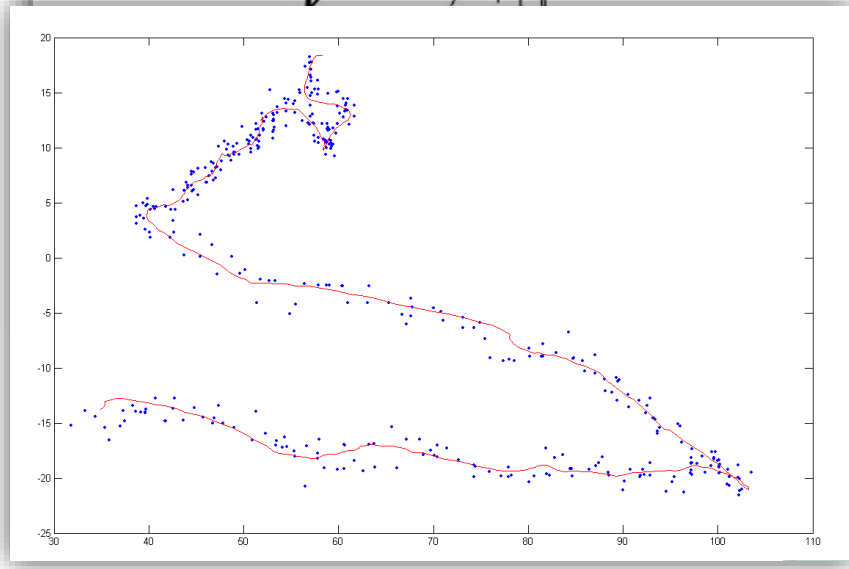
After

Unmanned Helicopter

Problems:

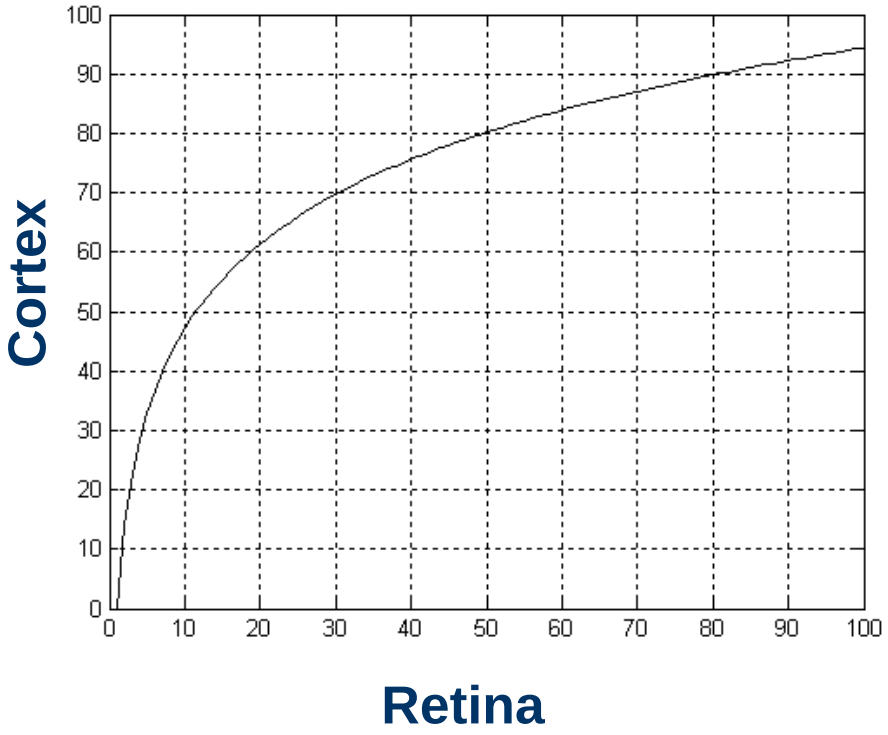
- Exhaust effect
- Unstable platform
- Oscillation (engine)





Unmanned Helicopter

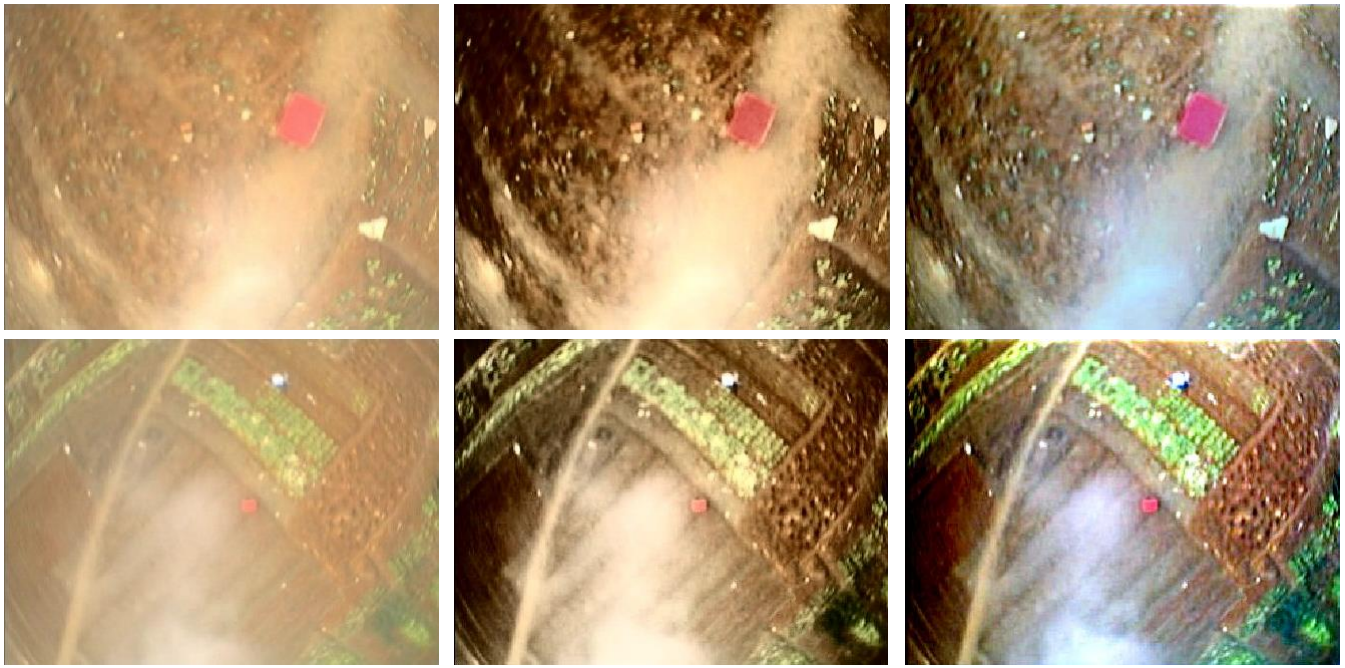
Retinex color enhancement



- Retina – Cortex
- Nonlinear mapping

Unmanned Helicopter

Color restoration:



Original

Histogram equalization

Multi-scale Retinex

Unmanned Helicopter

Brightness enhancement:

Original

Histogram equalization

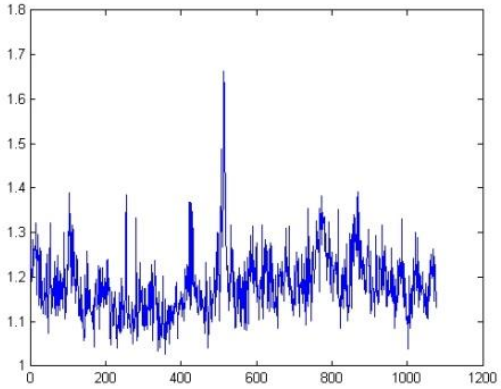
Multi-scale Retinex

Unmanned Helicopter

Target recognition -- Moment invariants:

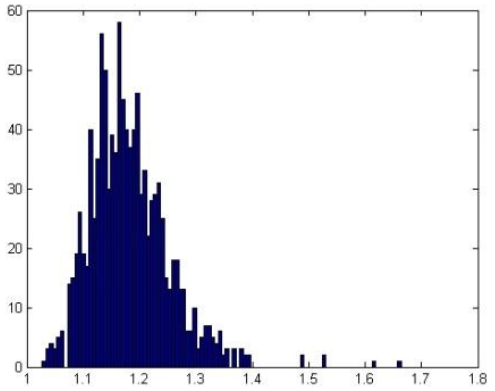
Training images

……

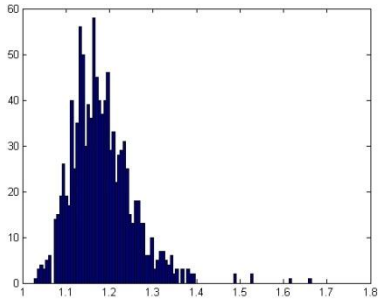


Moment invariants

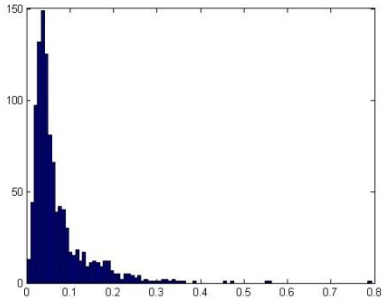
Histogram



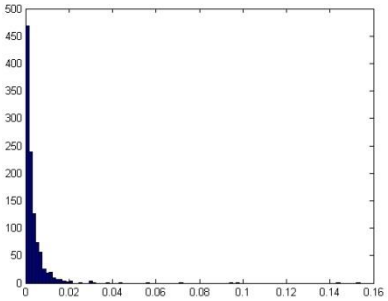
Unmanned Helicopter



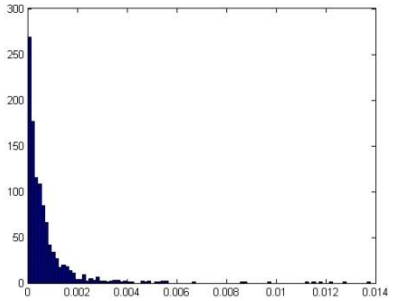
Hu_1



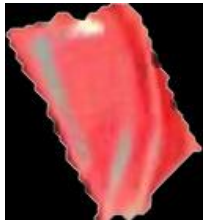
Hu_2

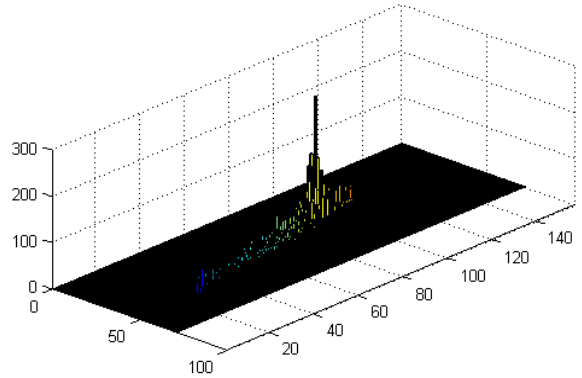


Hu_3



Hu_4





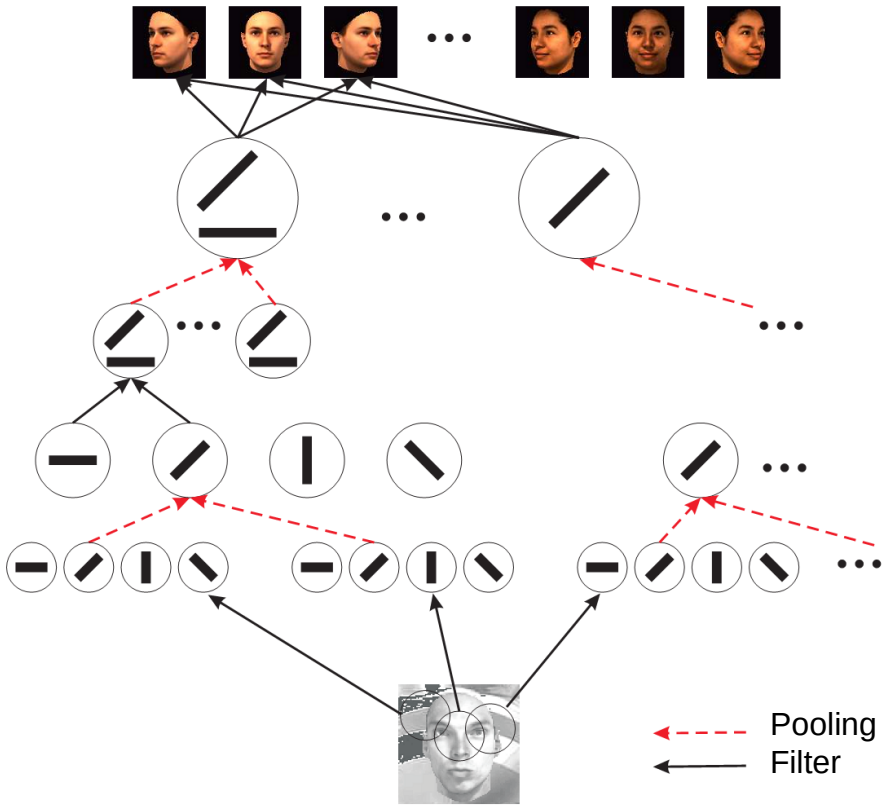
2D color histogram

$$P(Hu_1, Hu_2, Hu_3, Hu_4, Hist) =$$

$$w_1\chi_6^2\left(Hu_1\right) + w_2\chi_3^2\left(Hu_2\right) + w_3\chi_1^2\left(Hu_3\right) + w_4\chi_1^2\left(Hu_4\right) + w_5 h(Hist)$$

Unmanned Helicopter

HMAX model – Cortex:



Statistic analysis

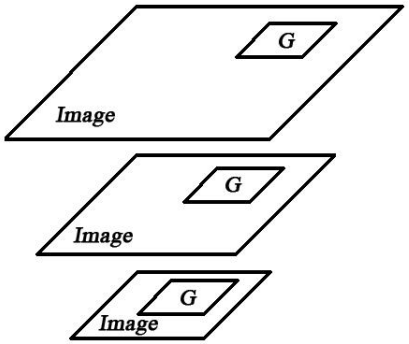
Bag of word

Max pooling

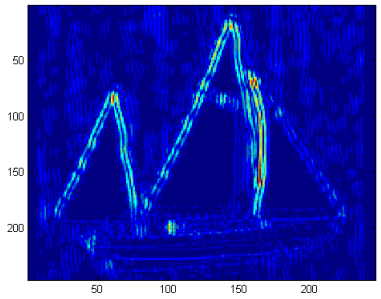
Gabor filter

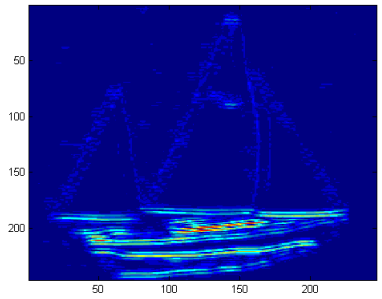
Unmanned Helicopter

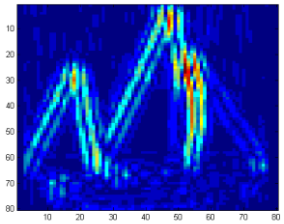
S1 – Gabor filter:

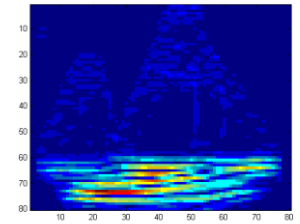


$$G(x,y) = \exp\left(-\frac{(x\cos\theta + y\sin\theta)^2 + \gamma^2(y\cos\theta - x\sin\theta)^2}{2\sigma^2}\right) \times \cos\left(\frac{2\pi(x\cos\theta + y\sin\theta)}{\lambda}\right)$$



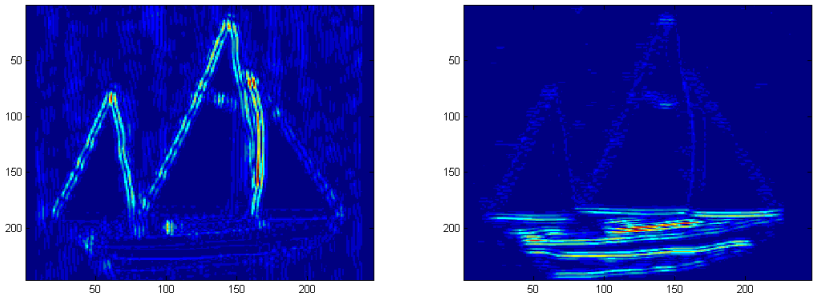


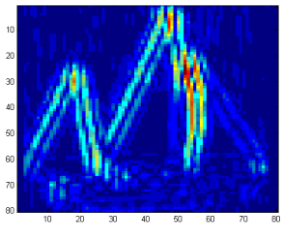


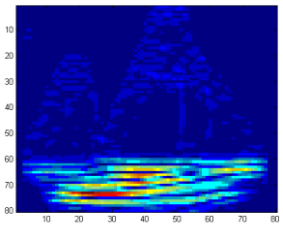


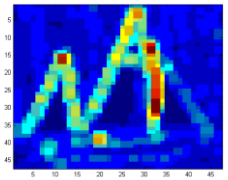
Unmanned Helicopter

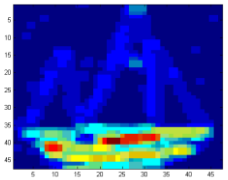
C1 – Max pooling



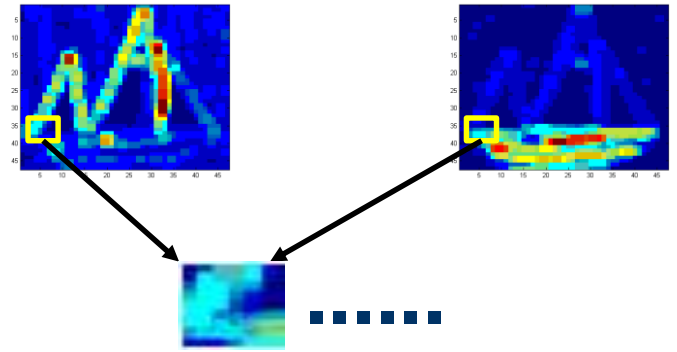




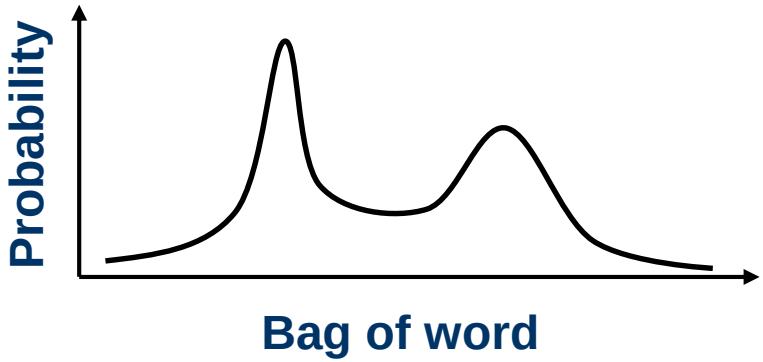




S2 – Bag of word

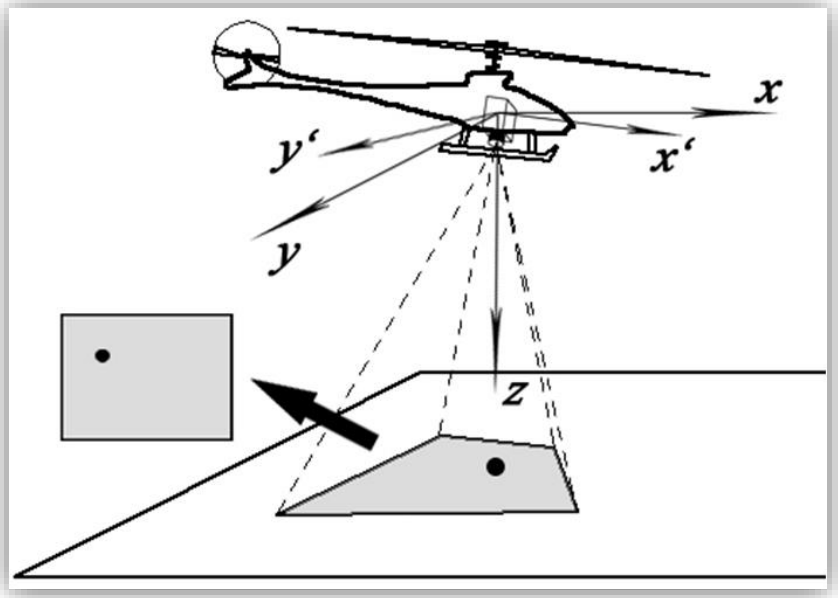


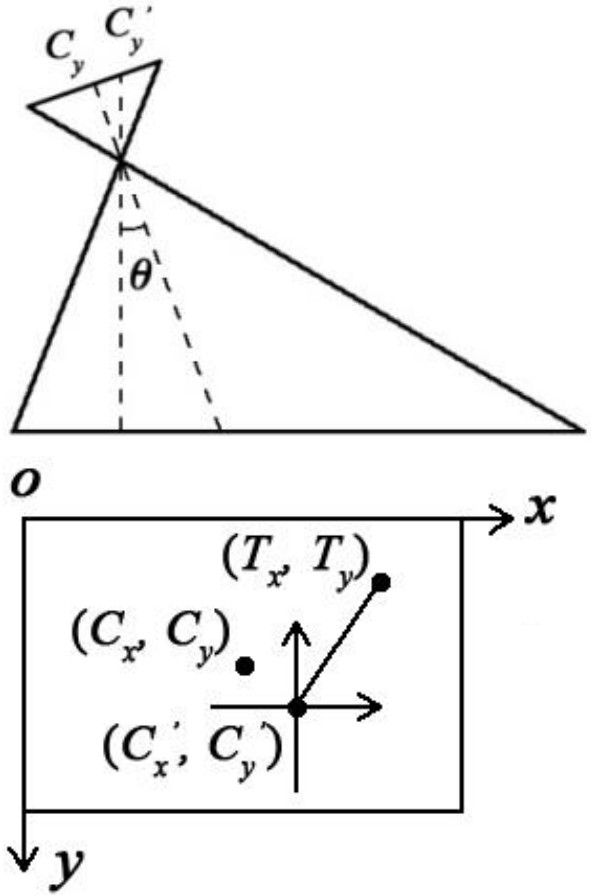
C2 – Statistic analysis



Unmanned Helicopter

Positioning in world coordinate system:





Unmanned Helicopter

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} P_2 & 0 \\ 0 & P_1 \end{pmatrix} \begin{pmatrix} -\tan\left(\arctan\dfrac{T_y - C_y}{P_2} - \theta\right) \\ \tan\left(\arctan\dfrac{T_x - C_x}{P_1} - \phi\right) \end{pmatrix}$$

$$P_1 = \frac{P_W}{2\tan\theta_{x\max}} \qquad P_2 = \frac{P_H}{2\tan\theta_{y\max}}$$

$$\vec{d} = h\left(\frac{X}{P_2}, \frac{Y}{P_1}\right) = h\left(-\tan(\arctan\frac{T_y - C_y}{P_2} - \theta), \tan(\arctan\frac{T_x - C_x}{P_1} - \phi)\right)$$

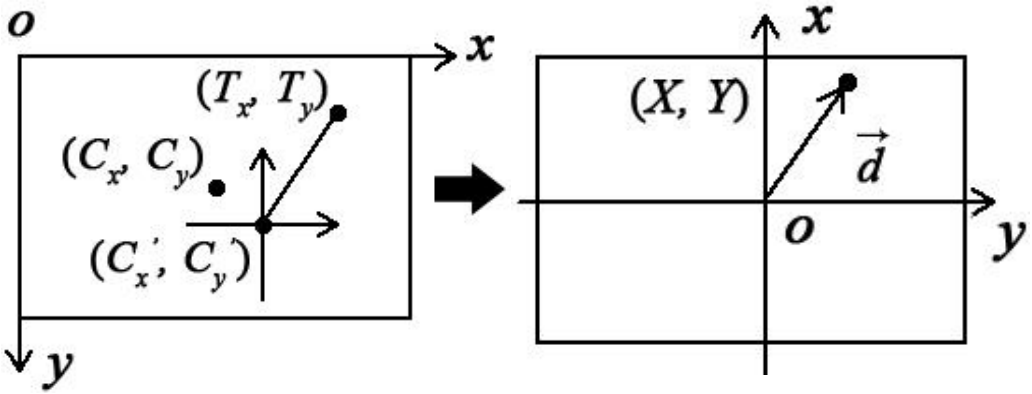
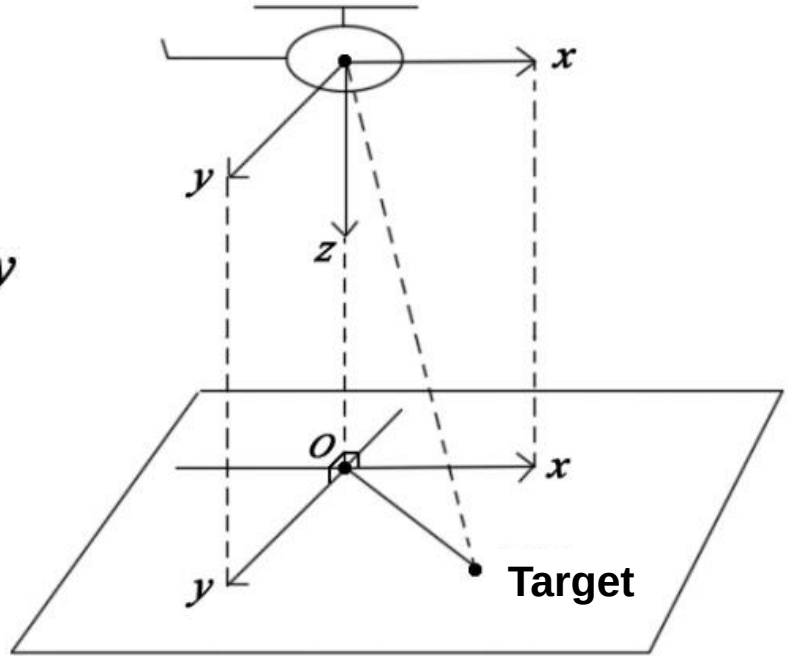


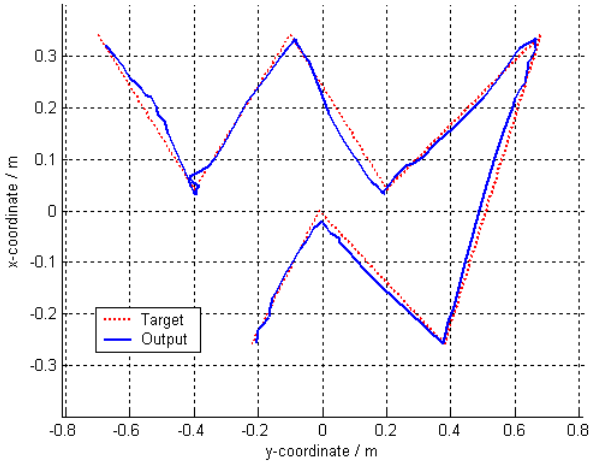
Image coordinate system

Body coordinate system

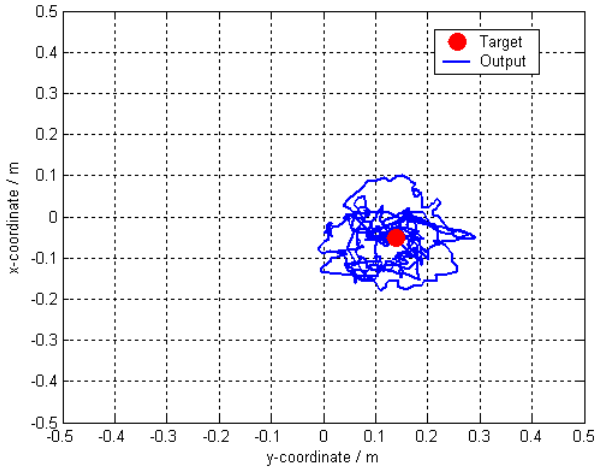


Unmanned Helicopter

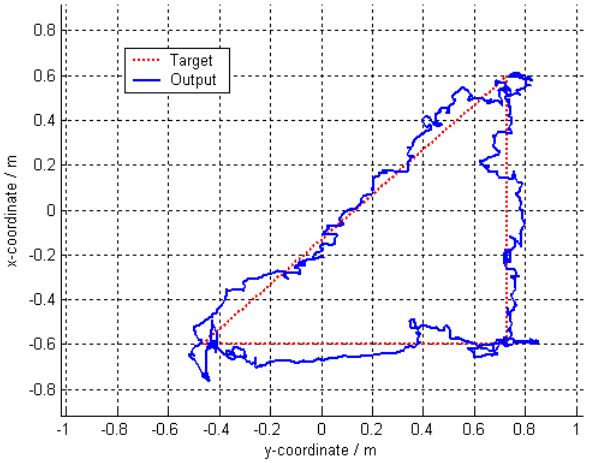
Simulated positioning test:



Normal state



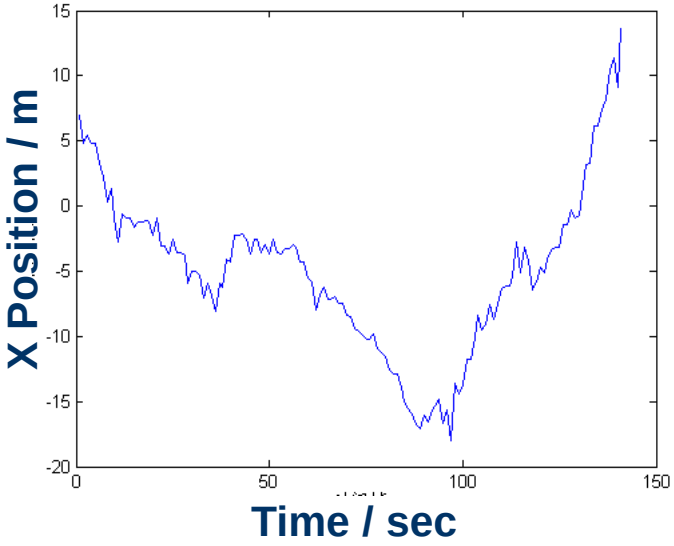
Abnormal state



Abnormal state

Unmanned Helicopter

Filter oscillation caused by engine:



$$\begin{cases} \hat{x}_{k+1/k} = \mathbf{F}\hat{x}_{k/k} + \mathbf{Q}_k \\ y_k = \mathbf{H}x_k + \mathbf{R}_k \end{cases}$$

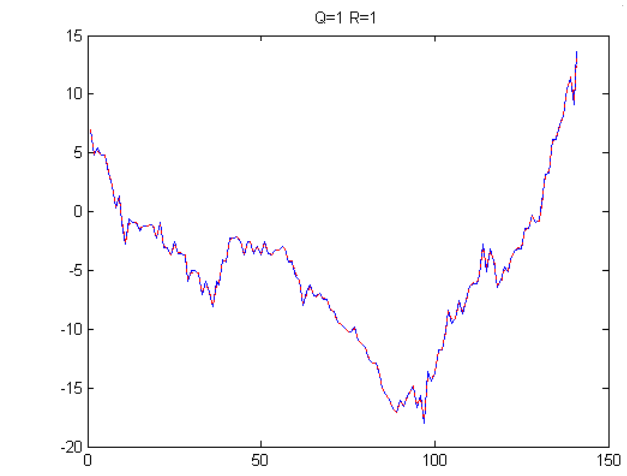
$$\mathbf{x}_k = \left(x, y, v_x, v_y\right)_k^{\mathrm{T}} \qquad \mathbf{F} = \begin{pmatrix} 1 & 0 & dt & 0 \\ 0 & 1 & 0 & dt \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \qquad \mathbf{Q}?$$

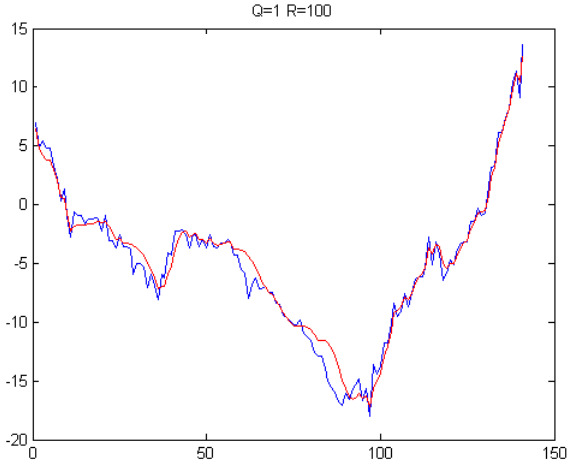
$$\mathbf{y}_k = \left(y_x, y_y\right)_k^{\mathrm{T}} \qquad \mathbf{H} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix} \qquad \mathbf{R}?$$

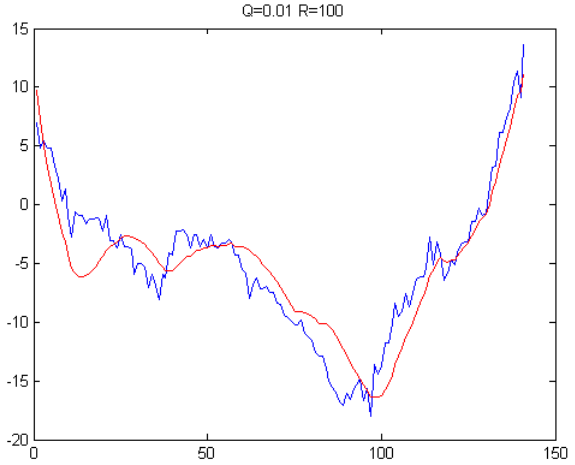
Unmanned Helicopter

Unscented Kalman Filter (UKF)

$$\begin{cases} \hat{x}_{k+1/k} = \mathbf{F}x_{k/k} + Q \cdot \mathbf{I} \\ y_k = \mathbf{H}x_k + R \cdot \mathbf{I} \end{cases}$$



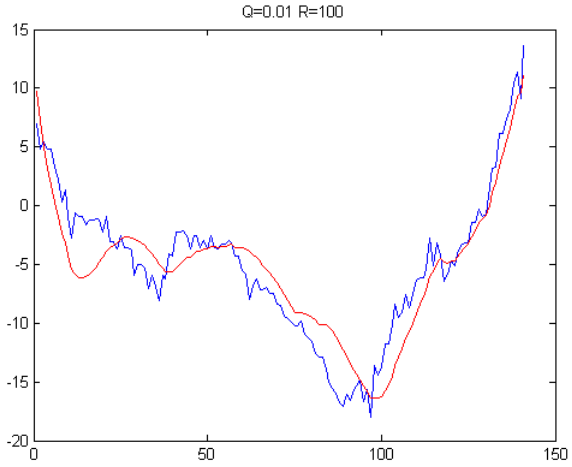




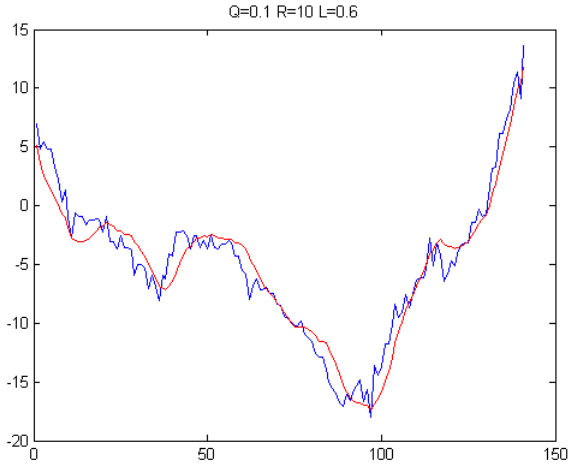
Unmanned Helicopter

UKF + DLF (Digital Low-pass Filter) = LUKF

$$\hat{x}_{k+1/k+1} = \hat{x}_{k+1/k} + K_{k+1}\left((1-L)y_{k+1} + L \cdot \mathbf{H}x_k - \hat{y}_{k+1/k}\right)$$



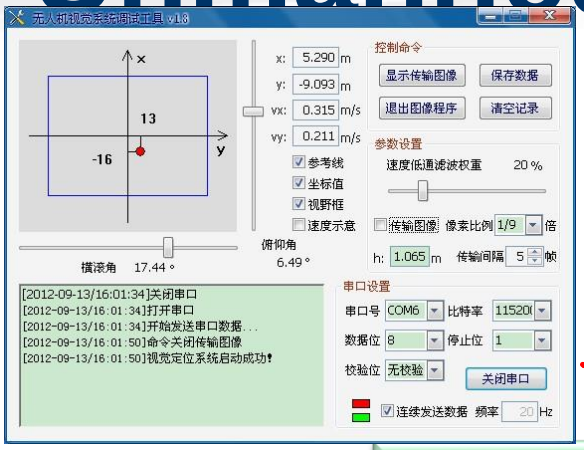
UKF

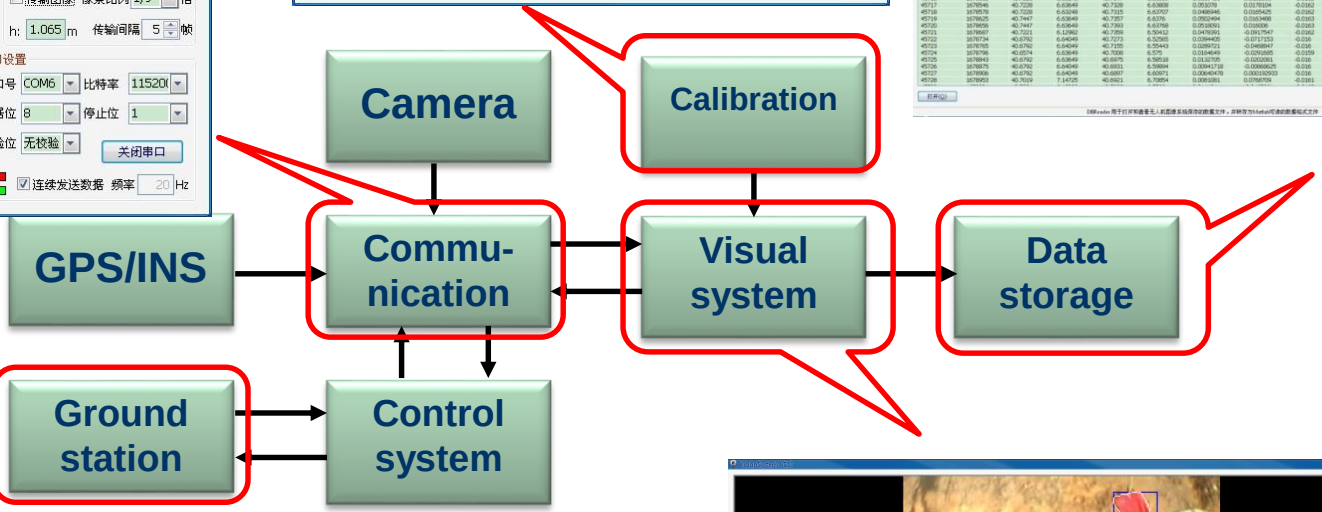


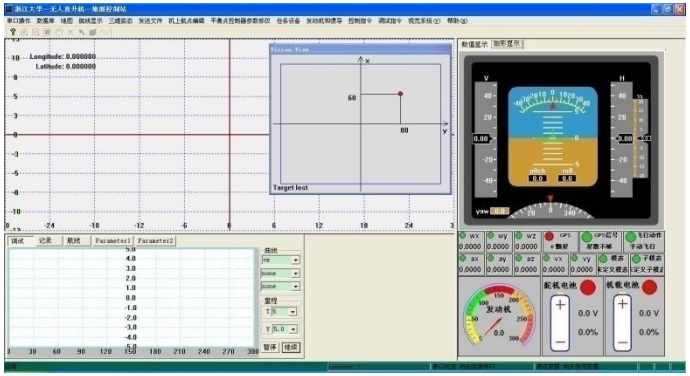
LUKF

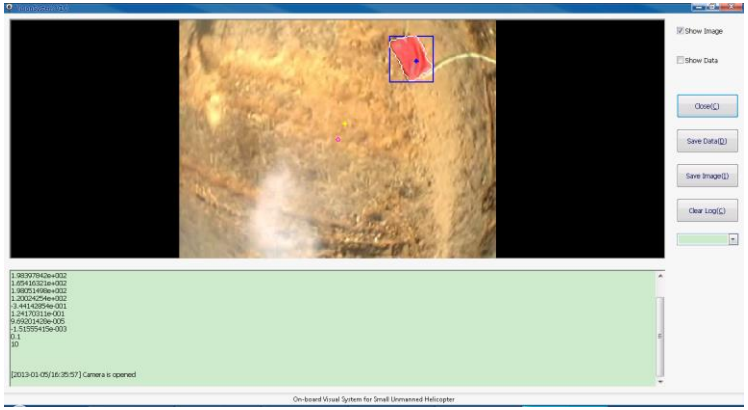
Unmanned


Calibration
自动标定
自动标定(C)
寻找角点返回值 0
棋盘横向内角点个数 6
棋盘纵向内角点个数 5
棋盘图片标定场景数 20
标定成功场景数 0
手动标定
抓图(G)
图片校验
图片标定
校正效果
当前文件名 无操作文件
棋盘横向内角点个数 6
棋盘纵向内角点个数 5
棋盘图片标定场景数 20
图像尺寸
320×240
关闭时自动保存所有设置
高级


无人机视觉系统测试工具 v1.0
x: 5.290 m
y: -9.093 m
vx: 0.315 m/s
vy: 0.211 m/s
控制命令
显示传输图像
保存数据
退出图像程序
清空记录
参数设置
速度(低通滤波权重 20 %
参考线
坐标值
视野框
速度示意
传输图像
像素比例 1/9 倍
h: 1.065 m
传输间隔 5 帧
俯仰角 6.49°
横滚角 17.44°
[2012-09-13/16:01:34]关闭串口
[2012-09-13/16:01:34]打开串口
[2012-09-13/16:01:34]开始发送串口数据...
[2012-09-13/16:01:50]命令:关闭传输图像
[2012-09-13/16:01:50]视觉定位系统启动成功!
串口设置
串口号 COM6
比特率 11520
数据位 8
停止位 1
校验位 无校验
关闭串口
连续发送数据 频率 20 Hz

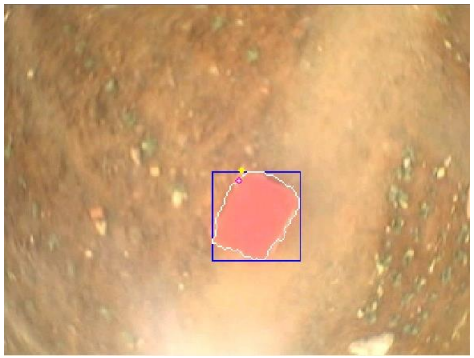

Camera
Calibration
GPS/INS
Commu-nication
Visual system
Data storage
Ground station
Control system

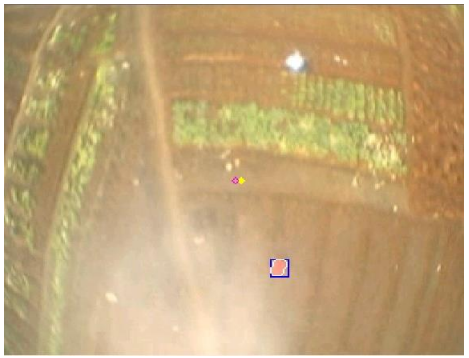
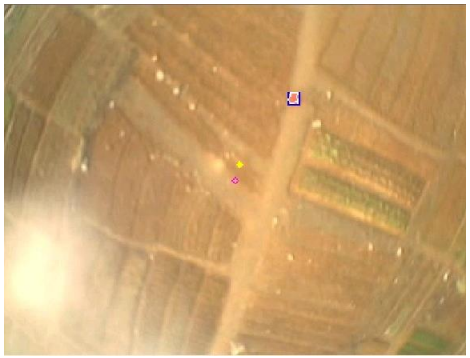


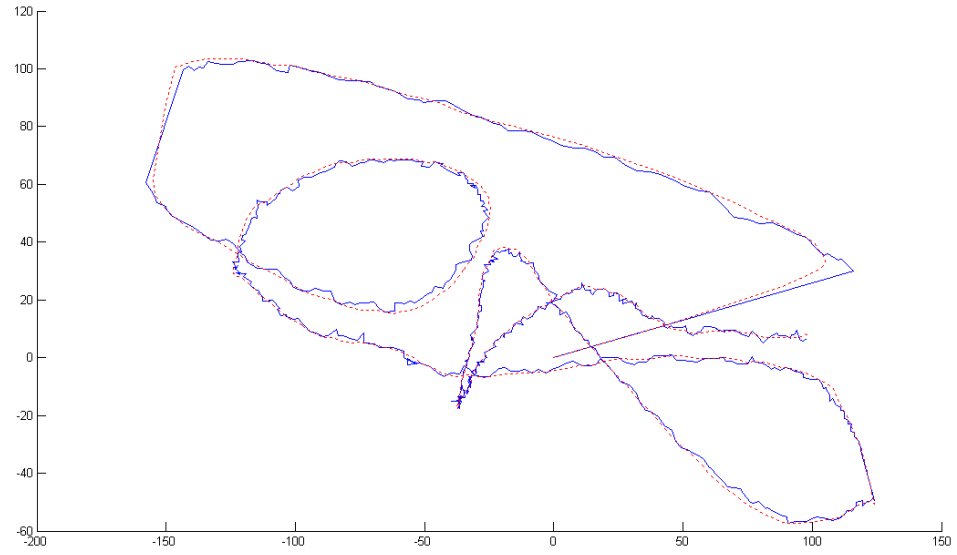


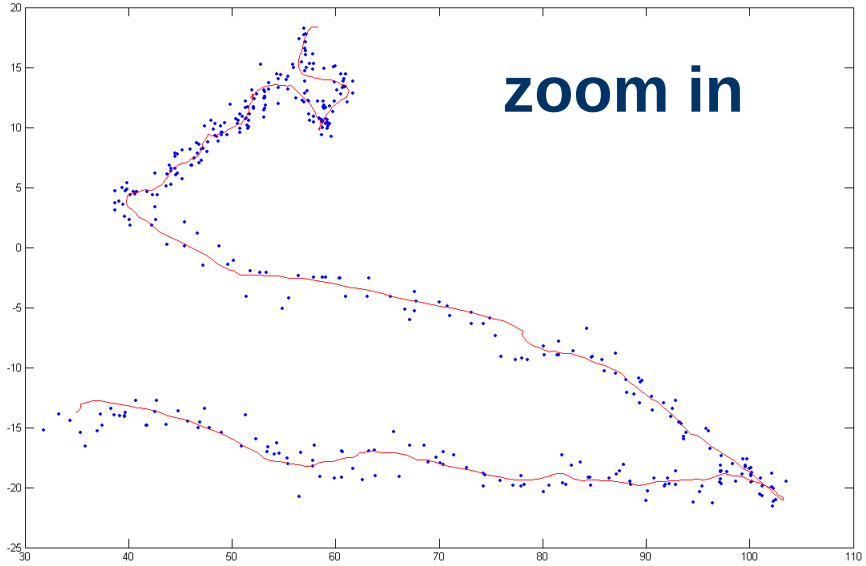
Unmanned Helicopter

Video



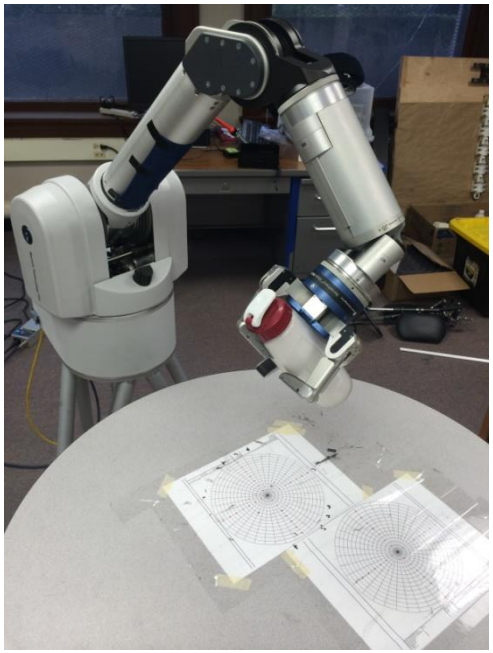




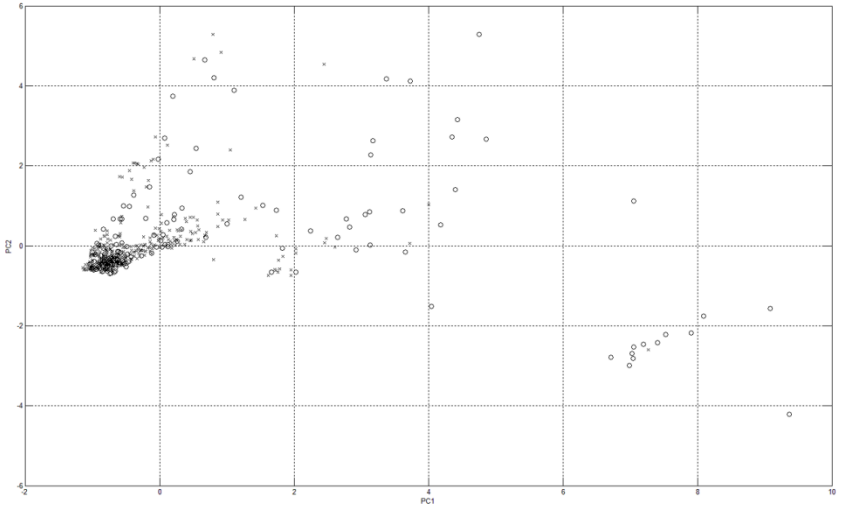
Robotic hand

Task:

Predict performance of robotic grasp to improve grasp quality of robotic hand.

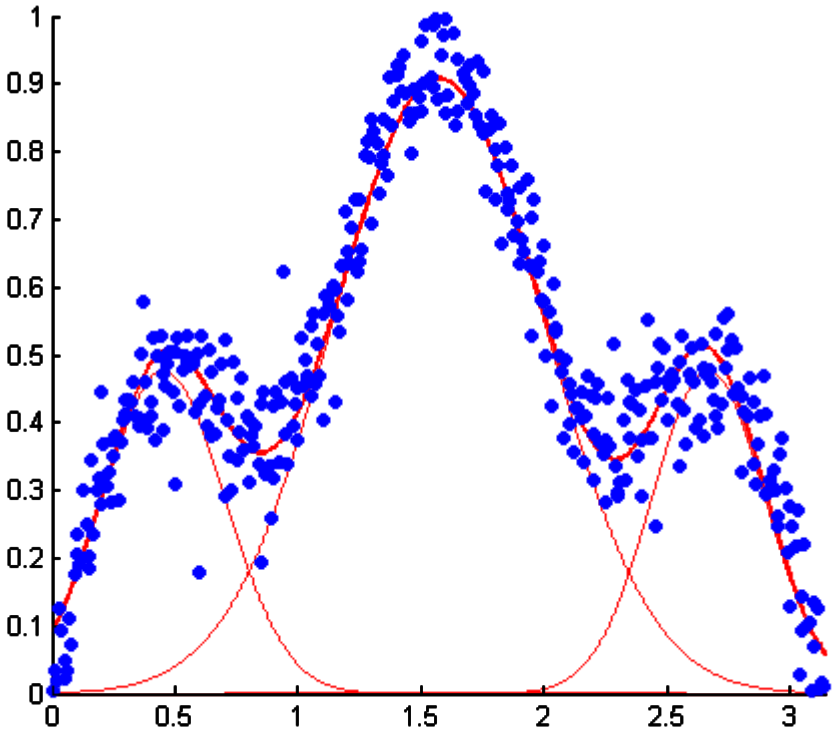


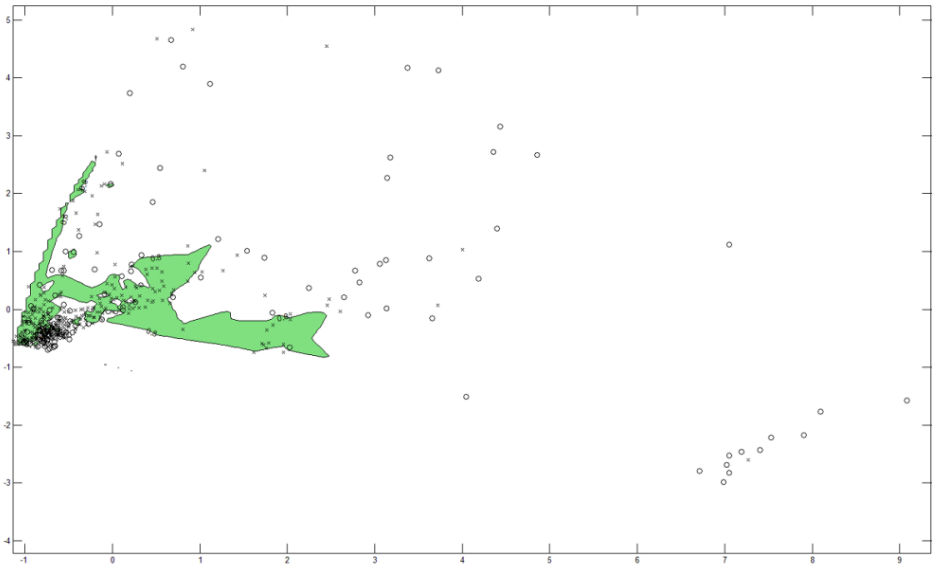
PCA + Info-Gain / T-test / Chi-squared



Robotic hand

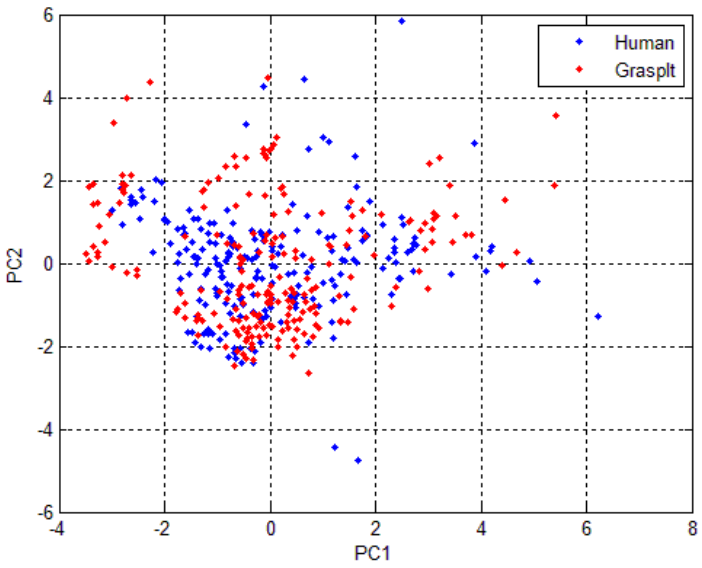
Gaussian processing

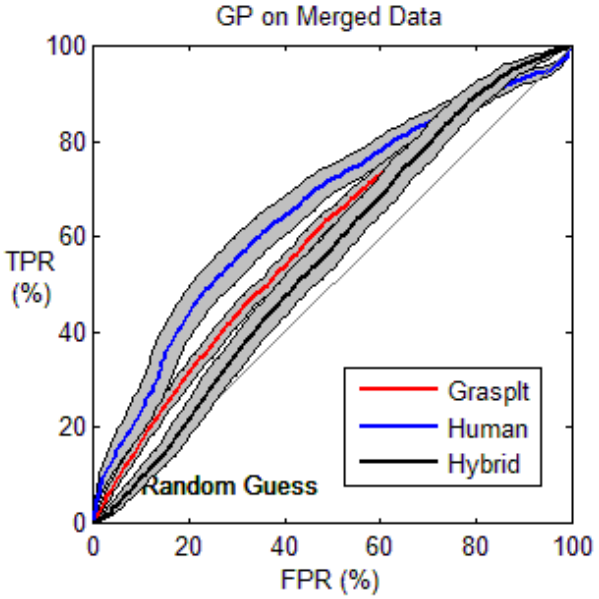




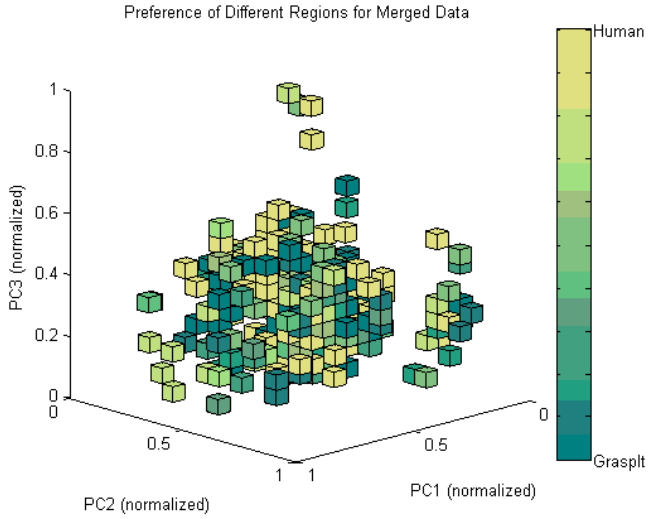
Robotic hand

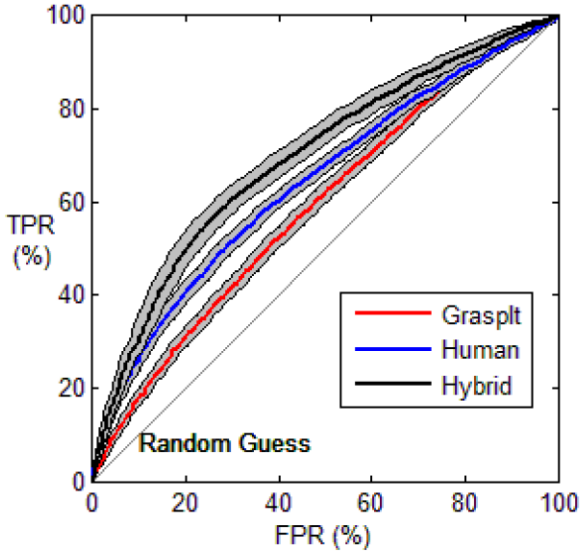
Hybrid Gaussian

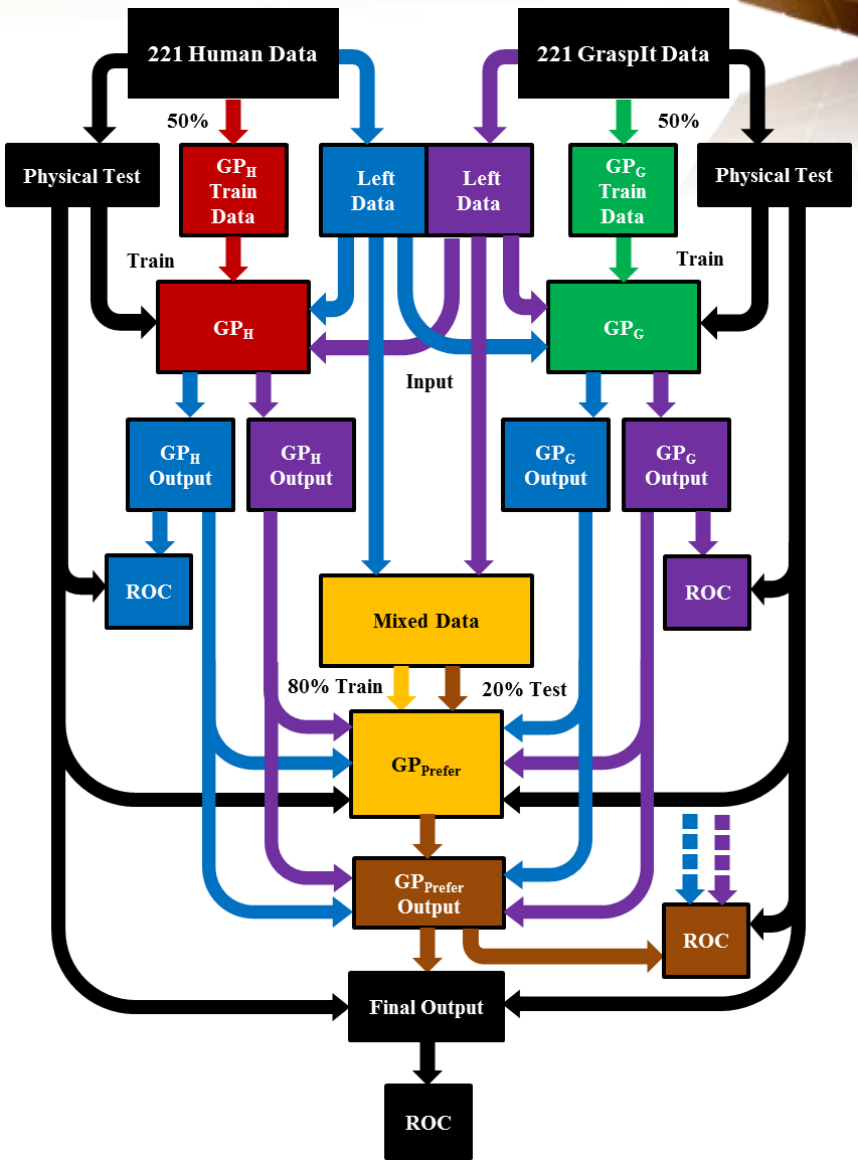




Robotic hand



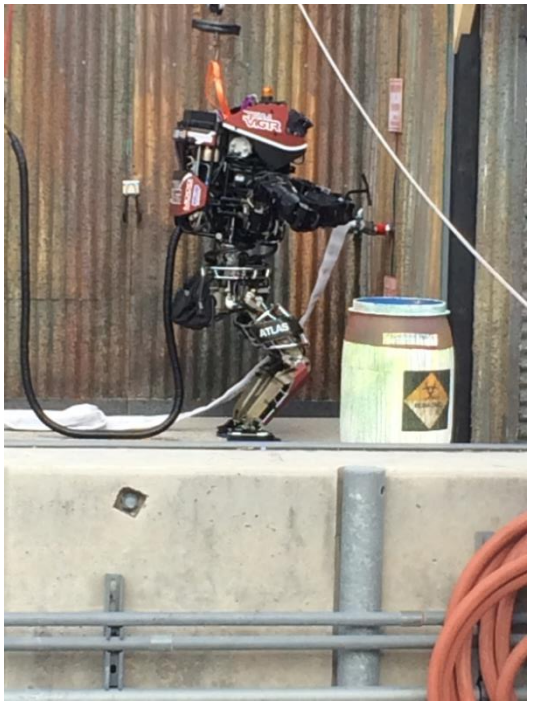




Robotic hand

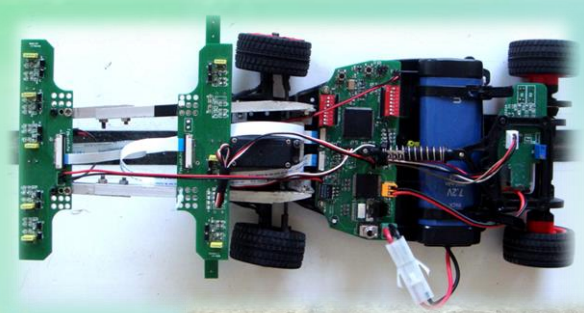
DARPA Robotics Challenge

Atlas with iRobot hand

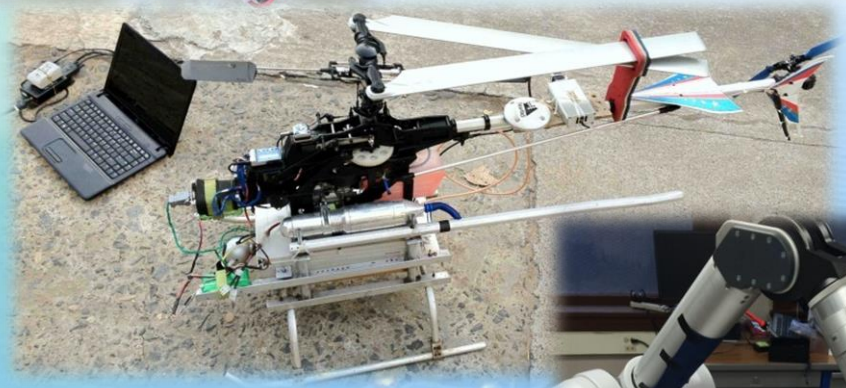


Connect a fire hose to a standpipe and tighten it up

2009



2010



2013

Thank you