实验室内部交流

刘成刚

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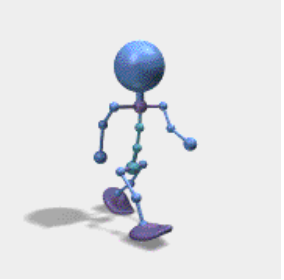
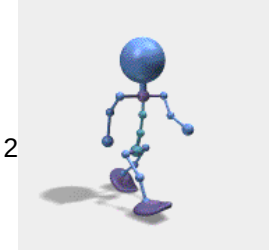


摘要

- 传感运动协调研究进展
- 仿人机器人进展
- 规划

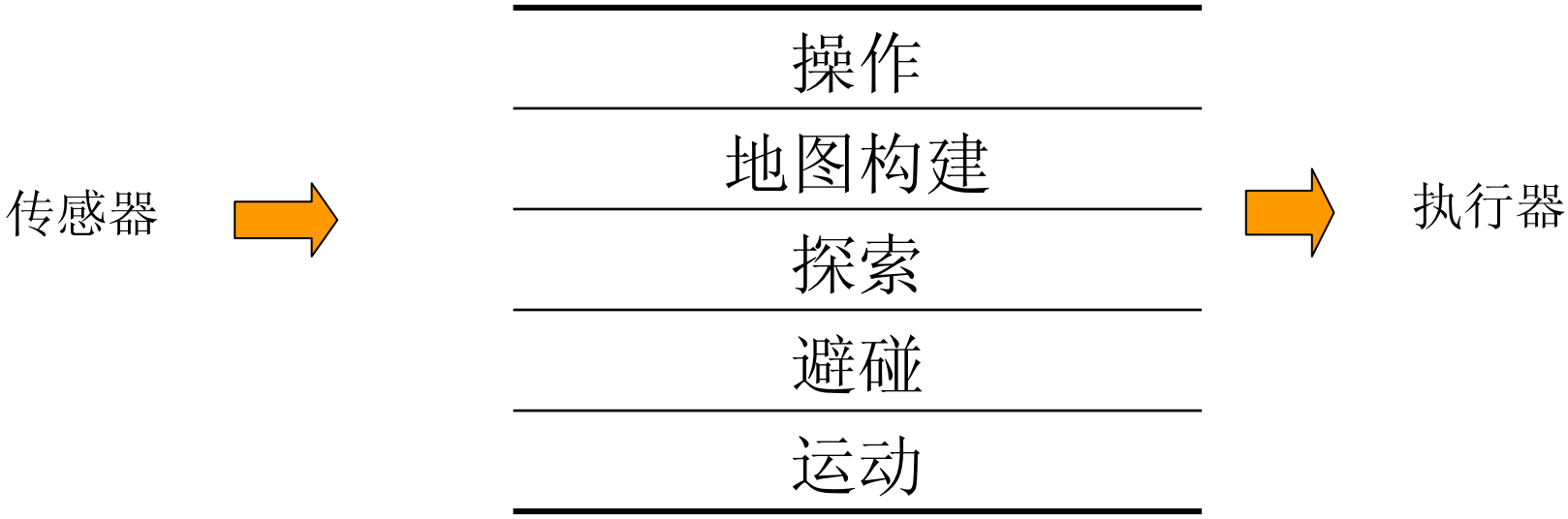
传感运动协调研究进展

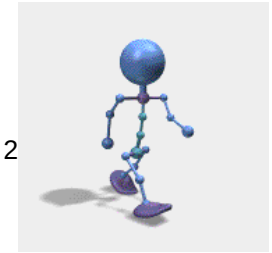
- 引言
- 方法
- 实验
- 结论



引言

例子：基于行为的移动机器人





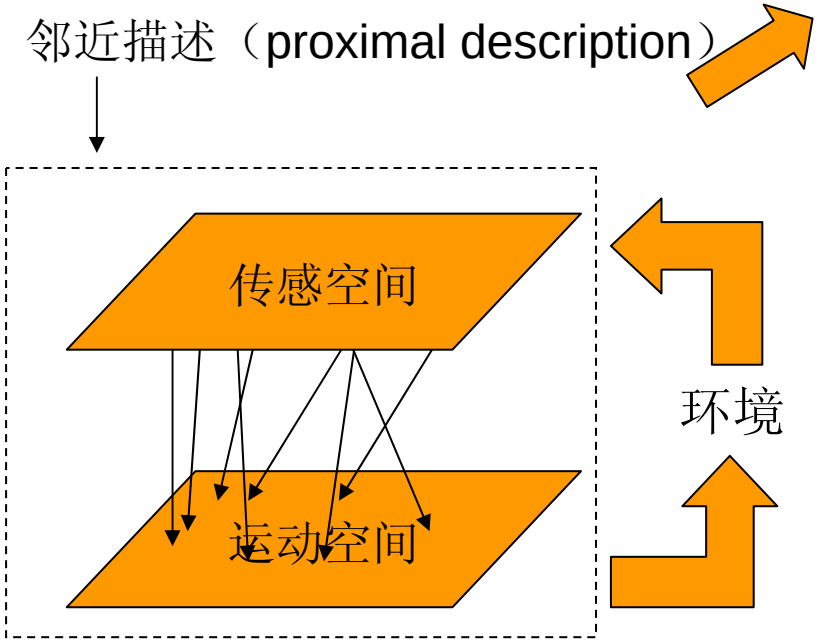
引言

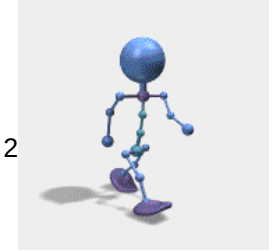
远侧描述 ⟶

(distal description)

操作
地图构建
探索
避碰
运动

邻近描述（proximal description）



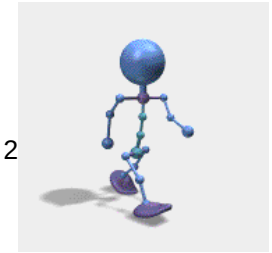


问题

- 如何通过机器人与环境的交互自己获得基本传感运动行为？

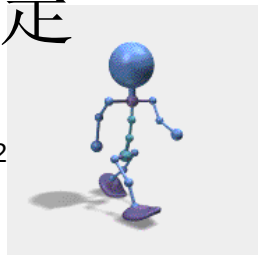
引言

- 稳定注视
  - 重要
  - 介于先天获得和后天学习之间
  - 实验简单、生物领域研究深入，拥有大量实验数据
  - 需要多种传感器的集成
    - 视觉：目标检测、光流
    - 非视觉：姿态传感器

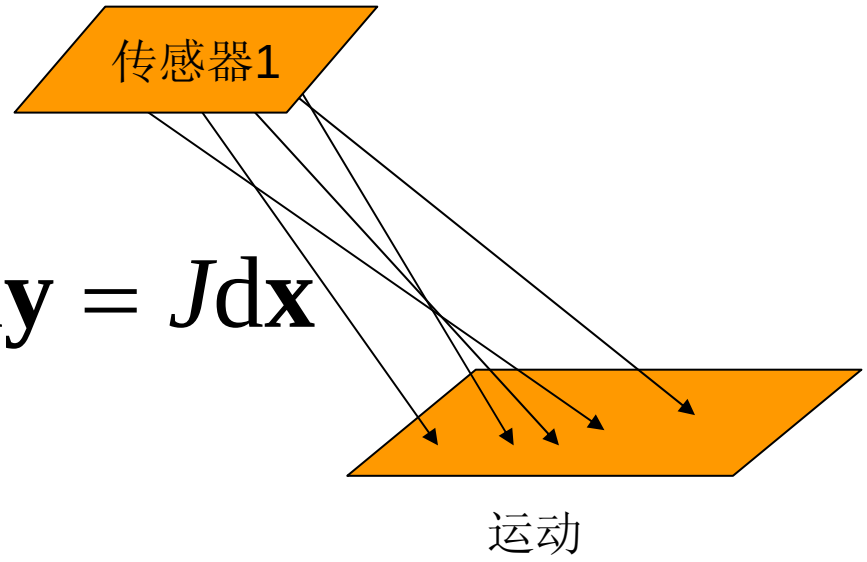


方法

1. 通过Jacobian矩阵刻画传感器与电机运动之间的映射关系
2. 通过不同传感器各自与电机运动之间的Jacobian矩阵建立相互关系并实现多种传感器的集成
3. Jacobian矩阵通过RLS在线辨识
4. 实现基于各种传感器的控制，机器人的行为由各个传感器的期望状态决定



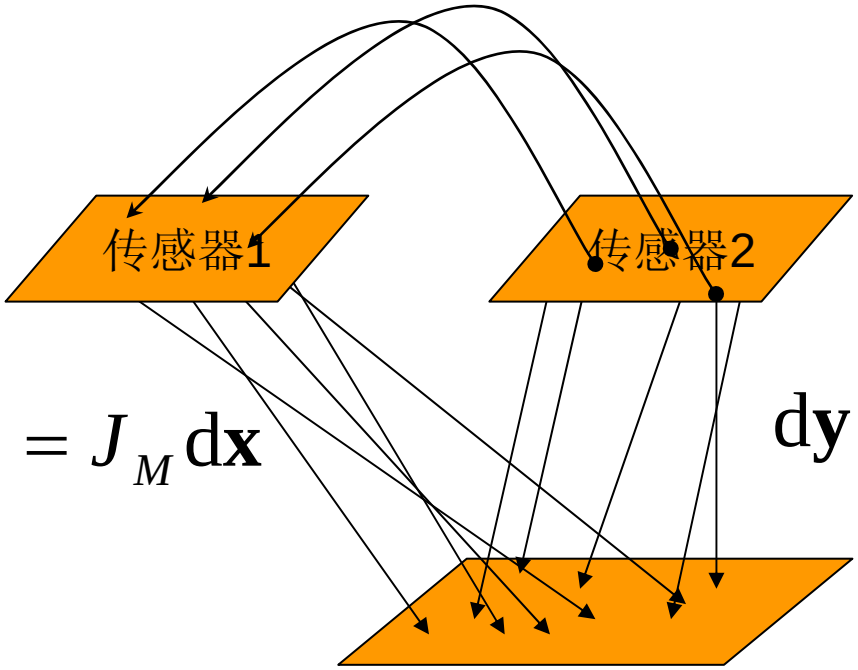
方法



$$\mathbf{dy} = J\mathbf{dx}$$

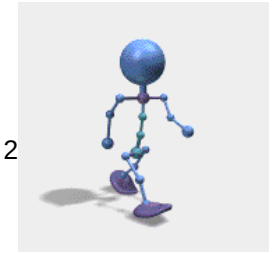
方法

$$\mathrm{d}\mathbf{y}^M = J_M J_N^* \mathrm{d}\mathbf{y}^N$$

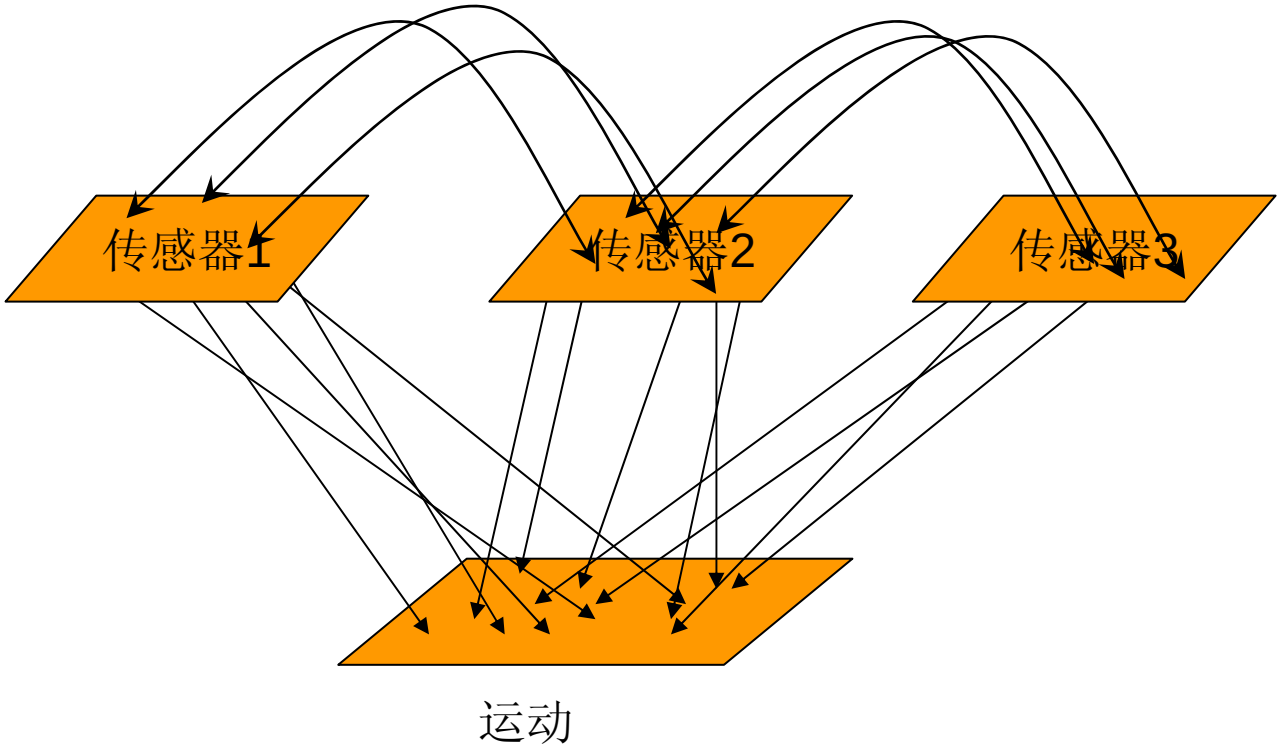


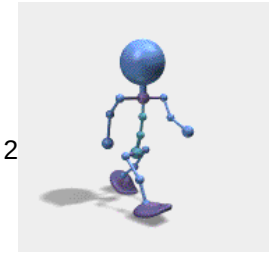
$$\mathrm{d}\mathbf{y}^M = J_M \mathrm{d}\mathbf{x}$$

$$\mathrm{d}\mathbf{y}^N = J_N \mathrm{d}\mathbf{x}$$



方法





方法

- 基于某个传感器的控制

$$\mathbf{u} = KJ^{*}(\mathbf{r} - \mathbf{y})$$

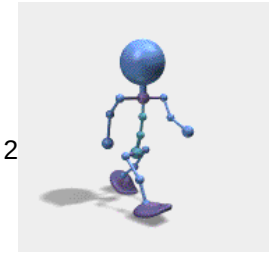
- 系统控制输入

$$\mathbf{u}_c = \mathrm{Merge}(\mathbf{u})$$

- 多传感器集成

$$\hat{\mathbf{y}}^{M}(t) = \mathbf{y}^{M}(kT) + \int_{kT}^{t} \mathrm{d}\mathbf{y}^{M}$$

$$= \mathbf{y}^{M}(kT) + J_M J_N^{*}[\mathbf{y}^{N}(t) - \mathbf{y}^{N}(kT)]$$



方法

RLS在线估计方法：

$$\theta(k+1)=\theta(k)$$

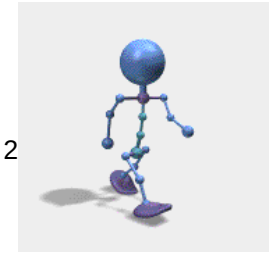
$$v(k)=\varphi(k)\theta(k)+v(k)$$

$$\theta(k)=[\mathbf{a}_1^T,\mathbf{a}_2^T,\cdots]^T$$

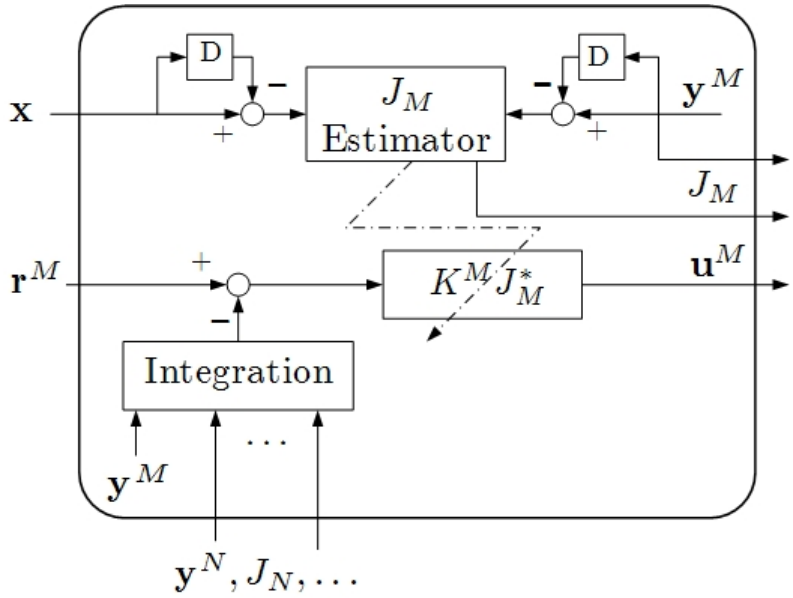
$$v(k)=\mathbf{y}(k)-\mathbf{y}(k-1)$$

$$\Delta\mathbf{x}(k)=\mathbf{x}(k)-\mathbf{x}(k-1)$$

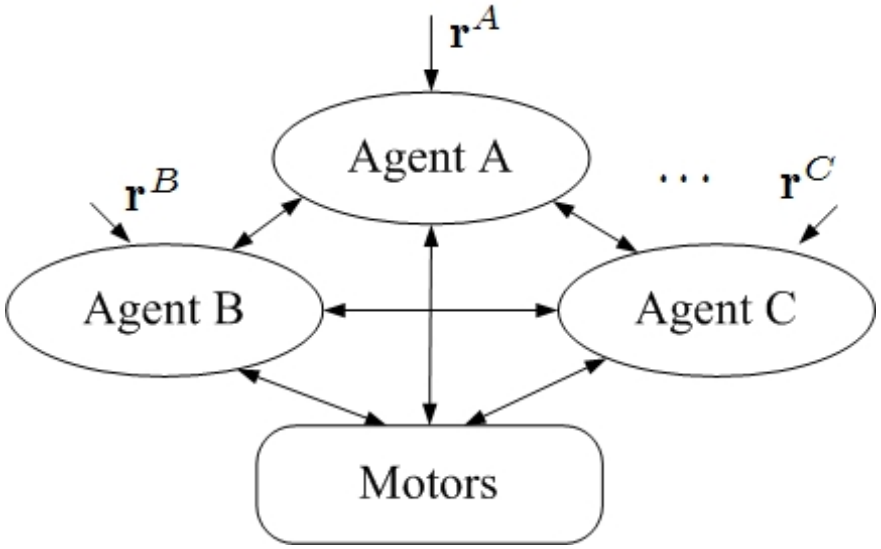
$$\varphi(k)=\begin{bmatrix}\Delta\mathbf{x}(k) & & 0\\ & \ddots & \\ 0 & & \Delta\mathbf{x}(k)\end{bmatrix}$$



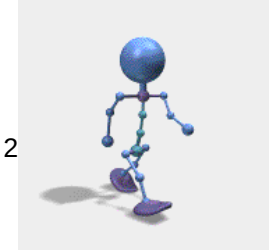
基于多智能体实现



单个智能体实现



多智能体模型实现

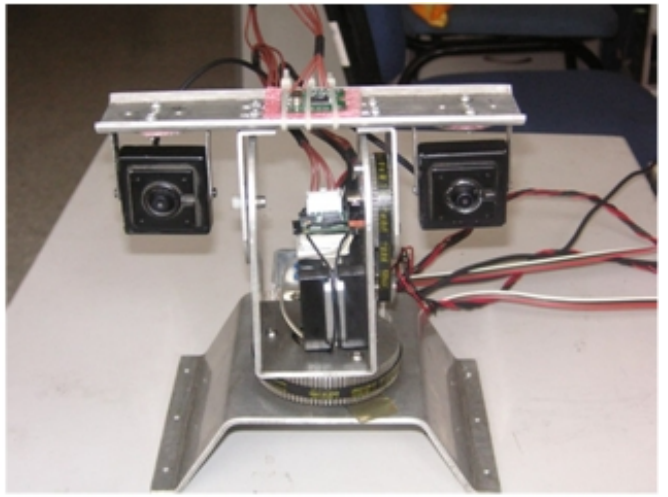


实验

- 目标检测传感器
  - 简单特征级联Boosted方法
- 图像滑移传感器
  - Lucas-Kanade光流计算方法
- 姿态检测传感器
  - 倾角传感器

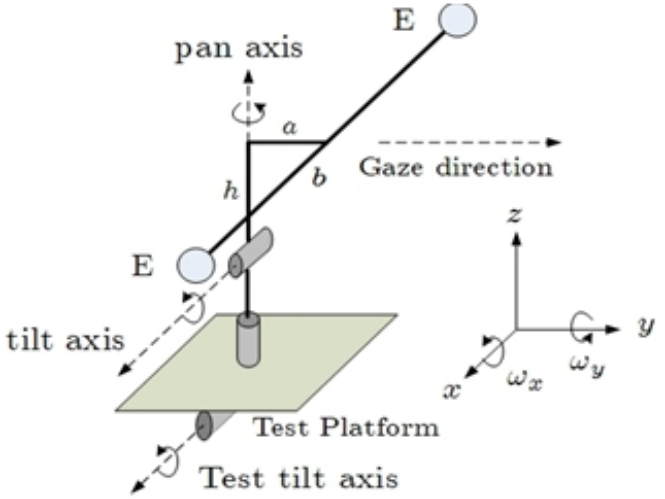
实验

(a)

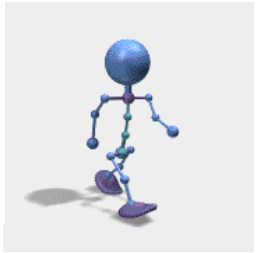


(b)

(c)


E
pan axis
a
b
h
Gaze direction
E
tilt axis
z
y
x
ω_x
ω_y
Test Platform
Test tilt axis

(d)



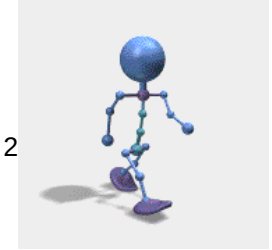
实验

$$\mathbf{y}_a = f_a(O(t), H(t))$$

$$\mathbf{y}_r = f_r(O(t), H(t))$$

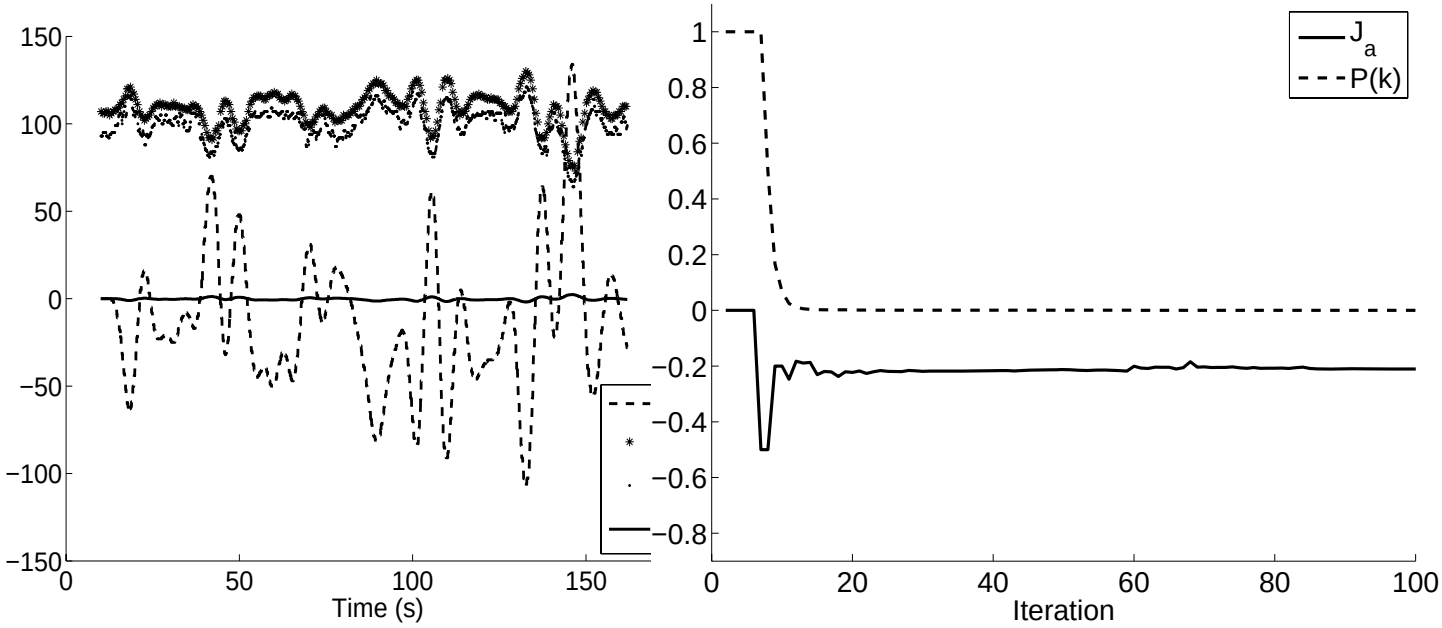
$$\mathbf{y}_v = f_v(H(t))$$

$$H(t) = \mathbf{x}(t) + I(t)$$

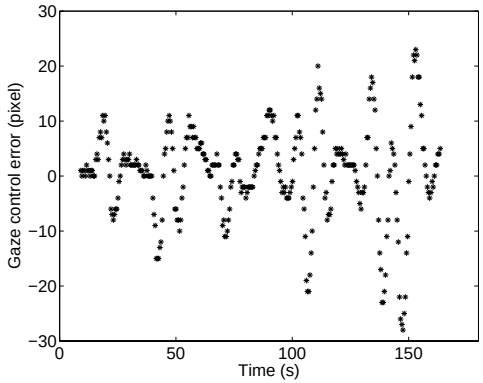


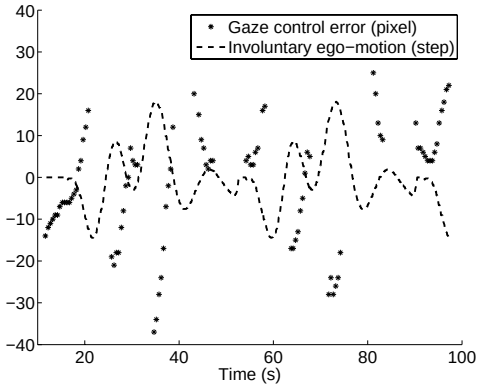
实验

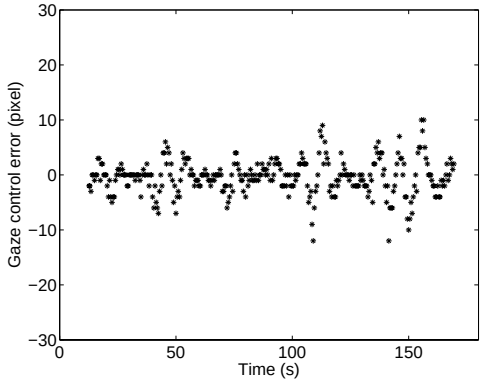
Jacobian矩阵在线估计

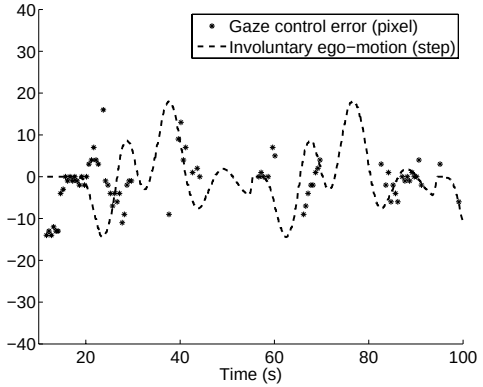


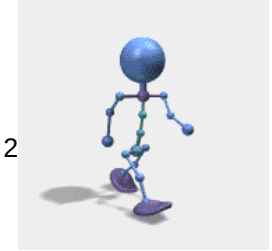
实验


Gaze control error (pixel)
Time (s)


Gaze control error (pixel)
Involuntary ego−motion (step)
Time (s)

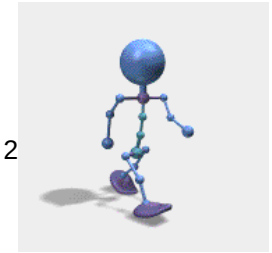

Gaze control error (pixel)
Time (s)


Gaze control error (pixel)
Involuntary ego−motion (step)
Time (s)



结论

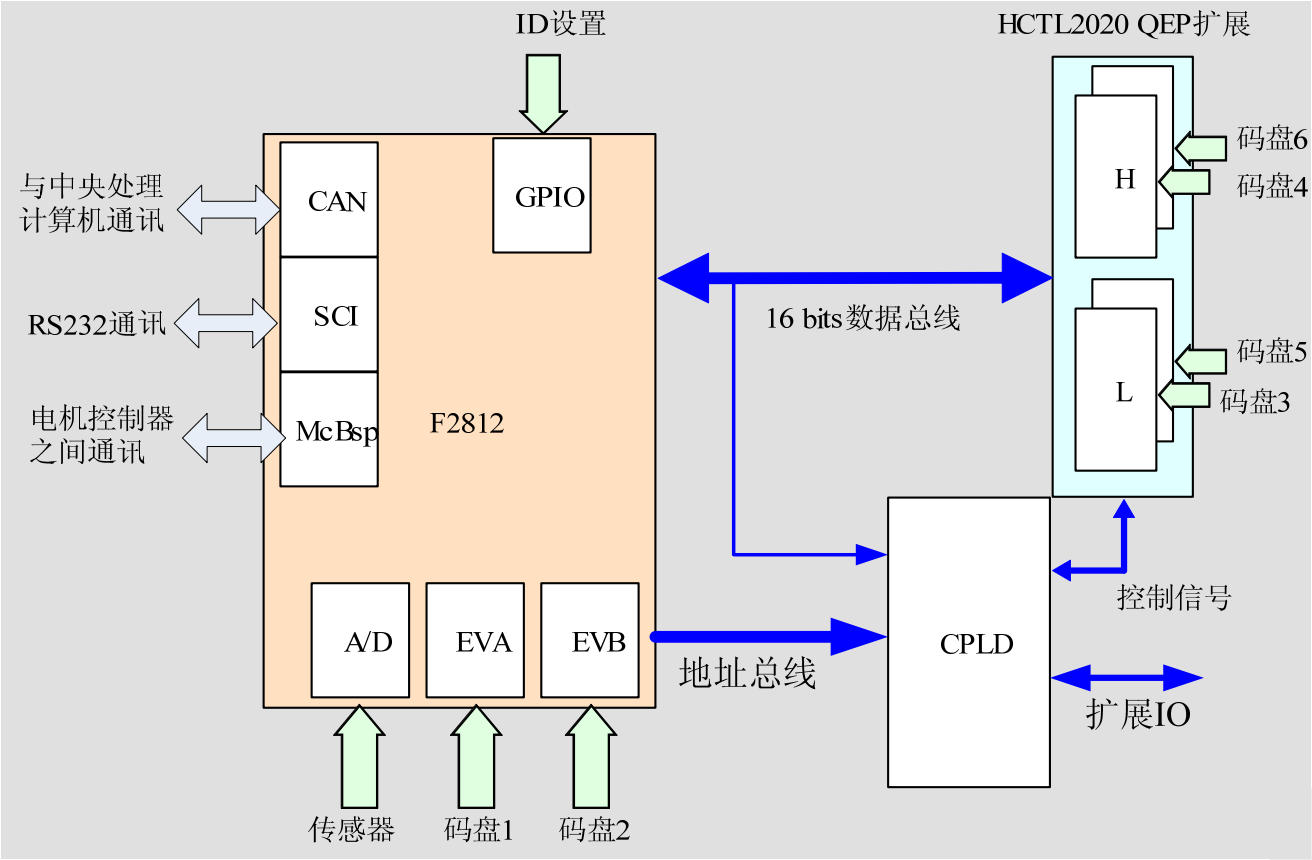
- 传感运动映射关系可以通过Jacobian矩阵刻画。
- 通过Jacobian在线估计实现在交互中获得基本行为。
- 通过两个传感器各自与电机运动之间的Jacobian矩阵实现两种传感器之间的集成从而实现多传感器集成。
- 多传感器集成提高控制性能、鲁棒性和减少计算资源的使用。



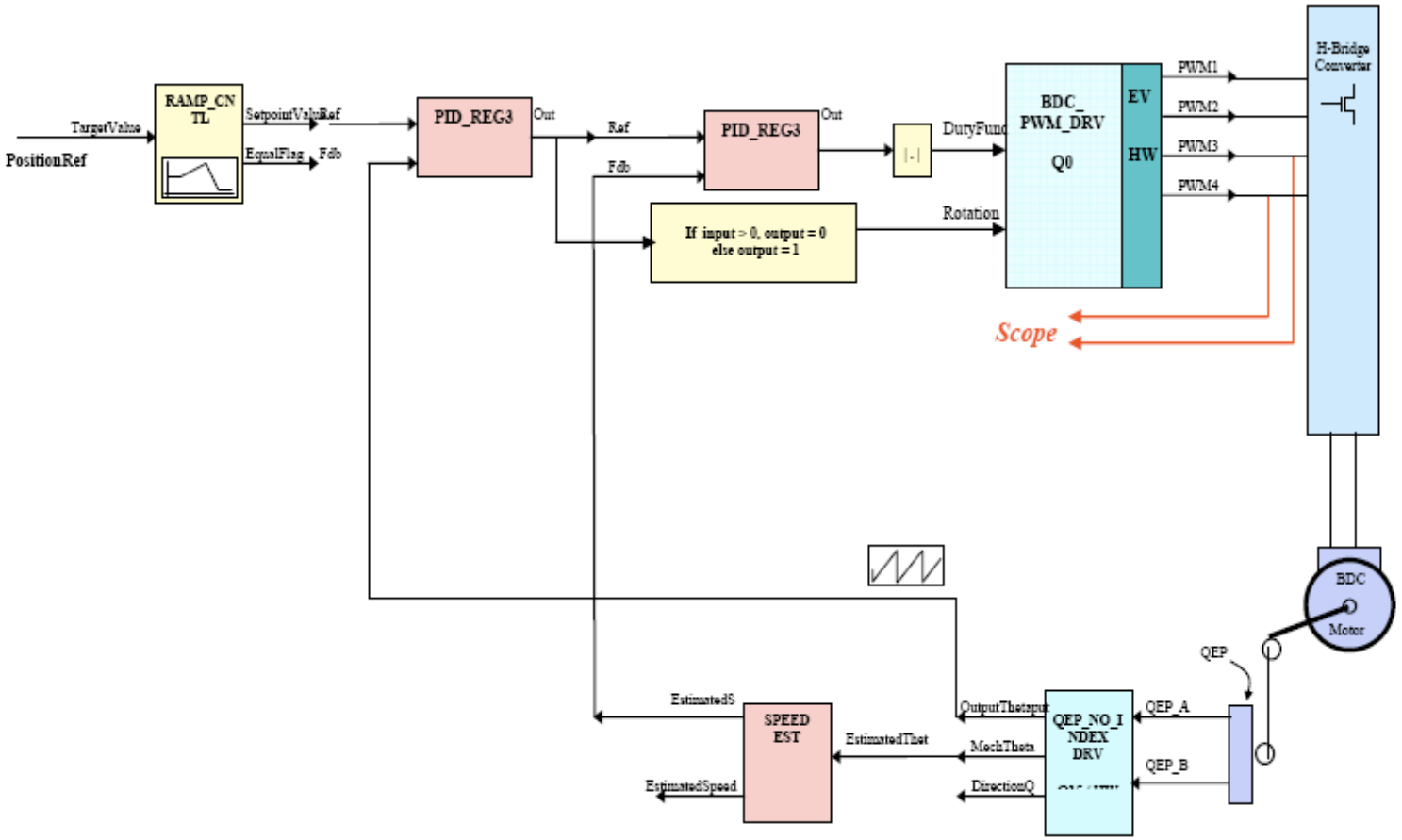
仿人机器人进展

- 关节控制
- 展望

关节控制


ID设置
HCTL2020 QEP扩展
与中央处理
计算机通讯
CAN
GPIO
RS232通讯
SCI
电机控制器
之间通讯
McBsp
F2812
H
L
码盘6
码盘4
码盘5
码盘3
16 bits数据总线
A/D
EVA
EVB
地址总线
CPLD
控制信号
扩展IO
传感器
码盘1
码盘2

关节控制


RAMP_CNTL
TargetValue
PositionRef
SetpointValRef
EqualFlag
Fdb
PID_REG3
Out
Ref
Fdb
PID_REG3
Out
|.|
DutyFunc
If input > 0, output = 0
else output = 1
Rotation
BDC_PWM_DRV
Q0
EV
HW
PWM1
PWM2
PWM3
PWM4
H-Bridge Converter
Scope
BDC Motor
QEP
QEP_A
QEP_B
QEP_NO_INDEX_DRV
OutputThetaput
MechTheta
DirectionQ
EstimatedThet
SPEED EST
EstimatedS
EstimatedSpeed

关节控制

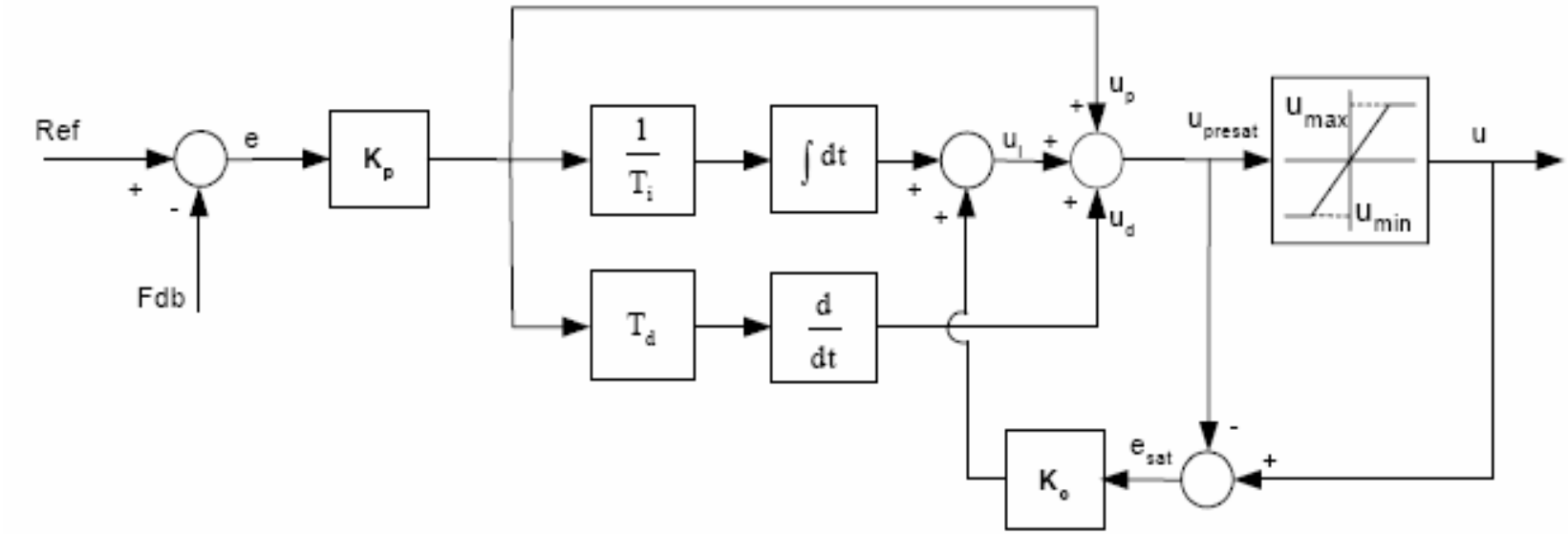
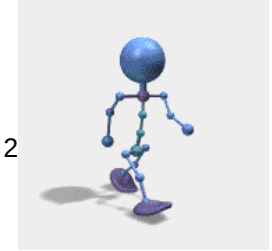
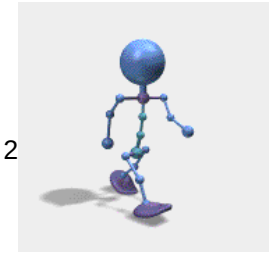


Figure 1: Block diagram of PID controller with anti-windup



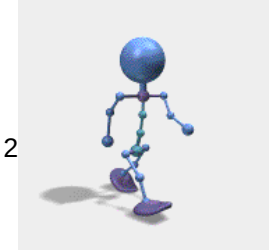
关节控制

- 强非线性
  - 模型非线性
  - 驱动器饱和
  - 齿轮间隙（gear backlash）
  - 控制/传感延时
- 参数辨识比较困难
- 轨迹跟踪误差比较大



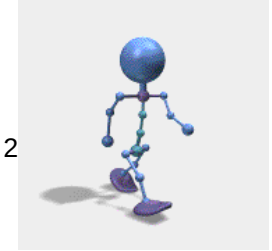
展望-开发

- 传感器：角度/角速度；压力
- 机构：冲击，悬挂点，脚底力传感
- 操作系统实时性：RTLinux/QNX



展望-研究

- 稳定判据
- 主动与被动 （利用齿轮间隙 -> 机构）
- 体系结构



谢谢