Gyrobot
a Two Wheel Balancing Robot

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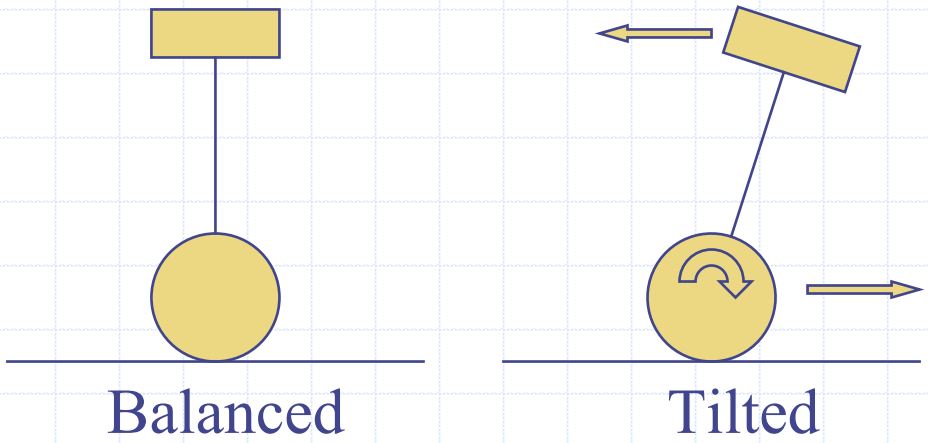
http://www.barello.net/Robots/Gyrobot

How Balancing Works

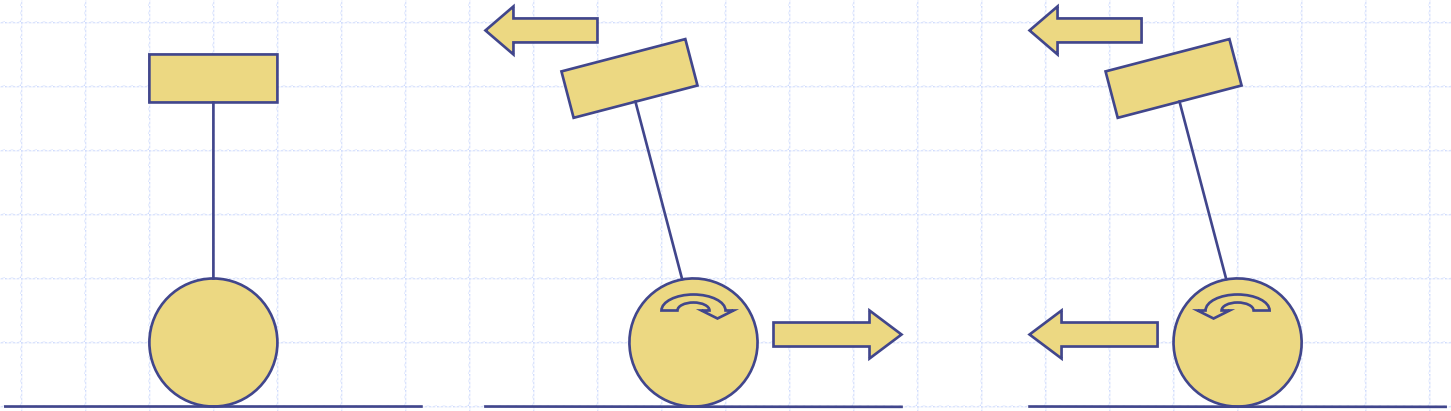
- Sense tilt and drive wheels to make robot erect.



- Drive = (90-angle) * Kangle
- Kangle is just a factor or gain.
- Easier to balance high GC object.

How to move

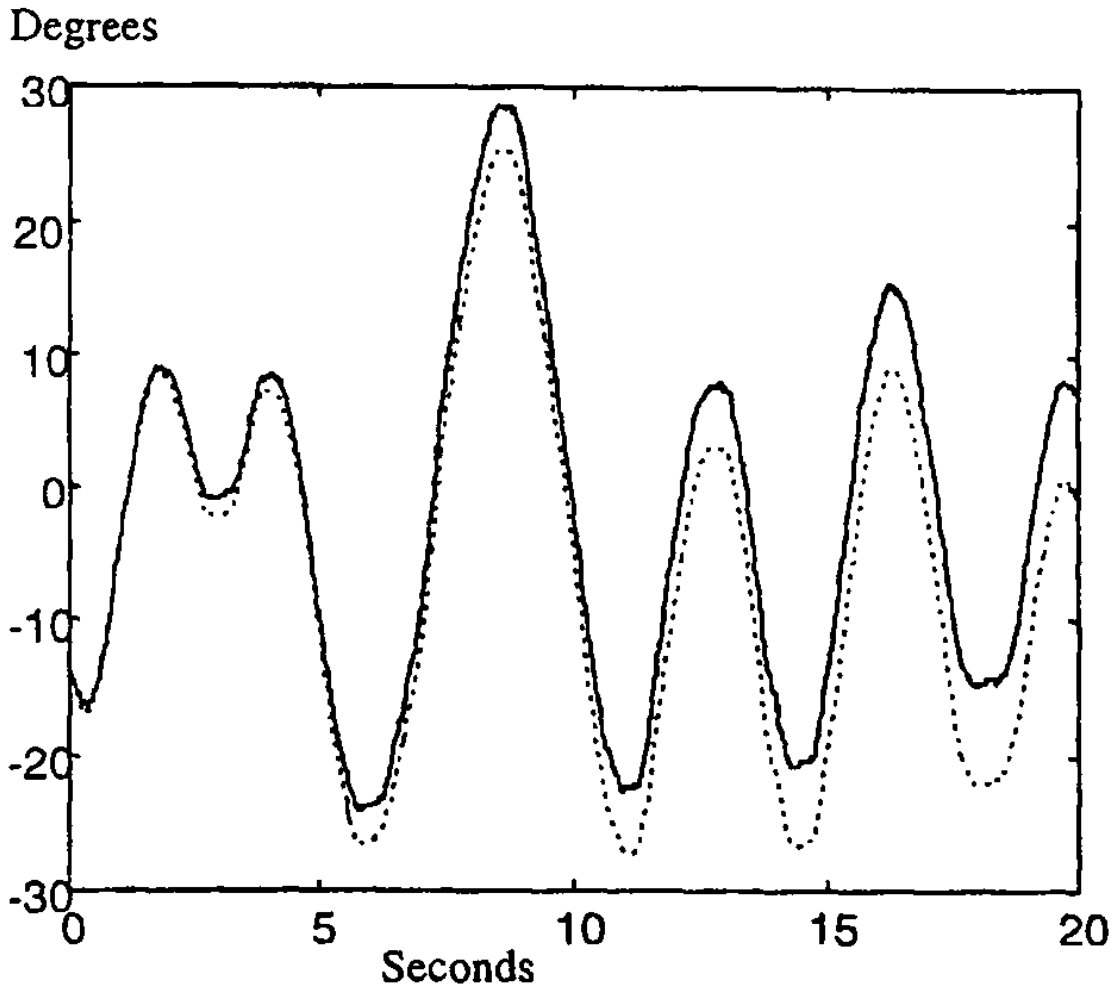
- The robot tilts in the direction of movement.



- Drive = (90-Angle) * Kangle – Velocity * Kp
- Velocity term drives robot backwards and tilts forward.
- The balance term drives robot forward.

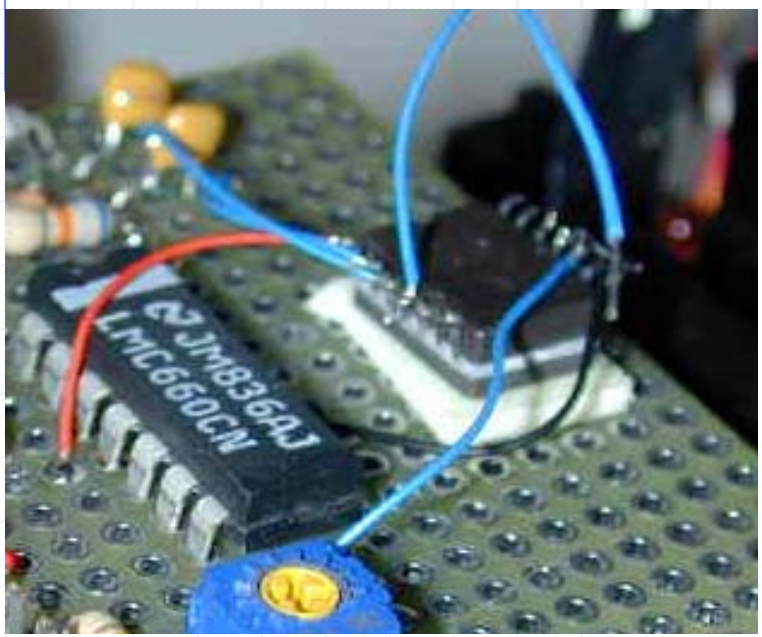
Tilt Sensor

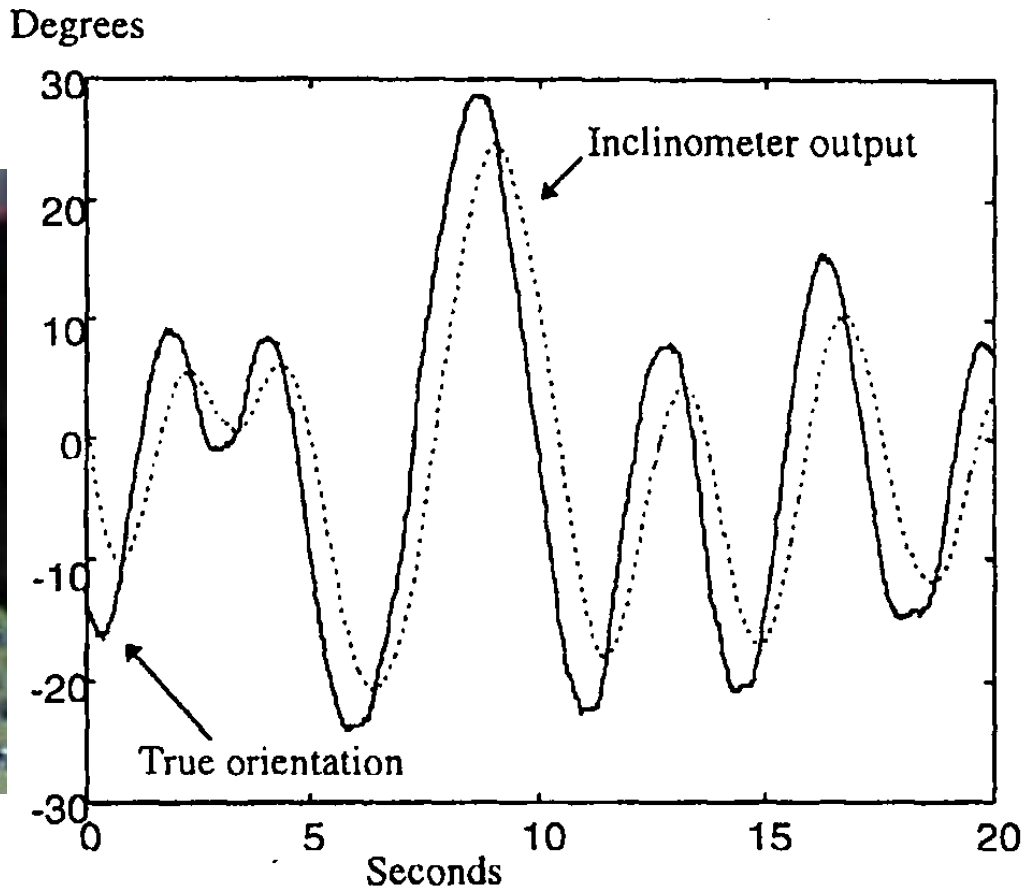
- Gyroscope measures Rate Of Turn.
- Integrate for angle
- Gyroscopes drift
- Drift changes with temperature



Tilt Sensor

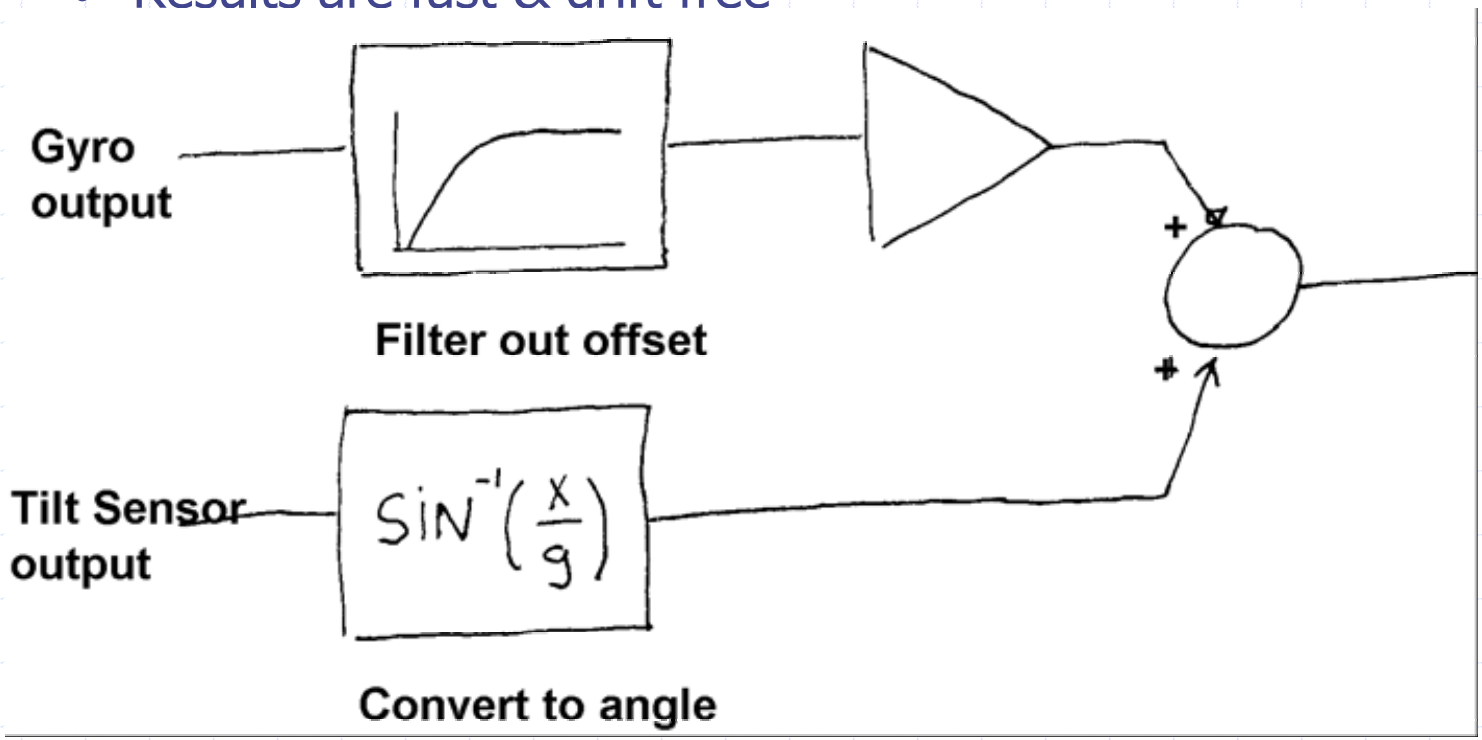
- Accelerometers measure gravity.
- Affected by movement.
- Slow, very accurate.



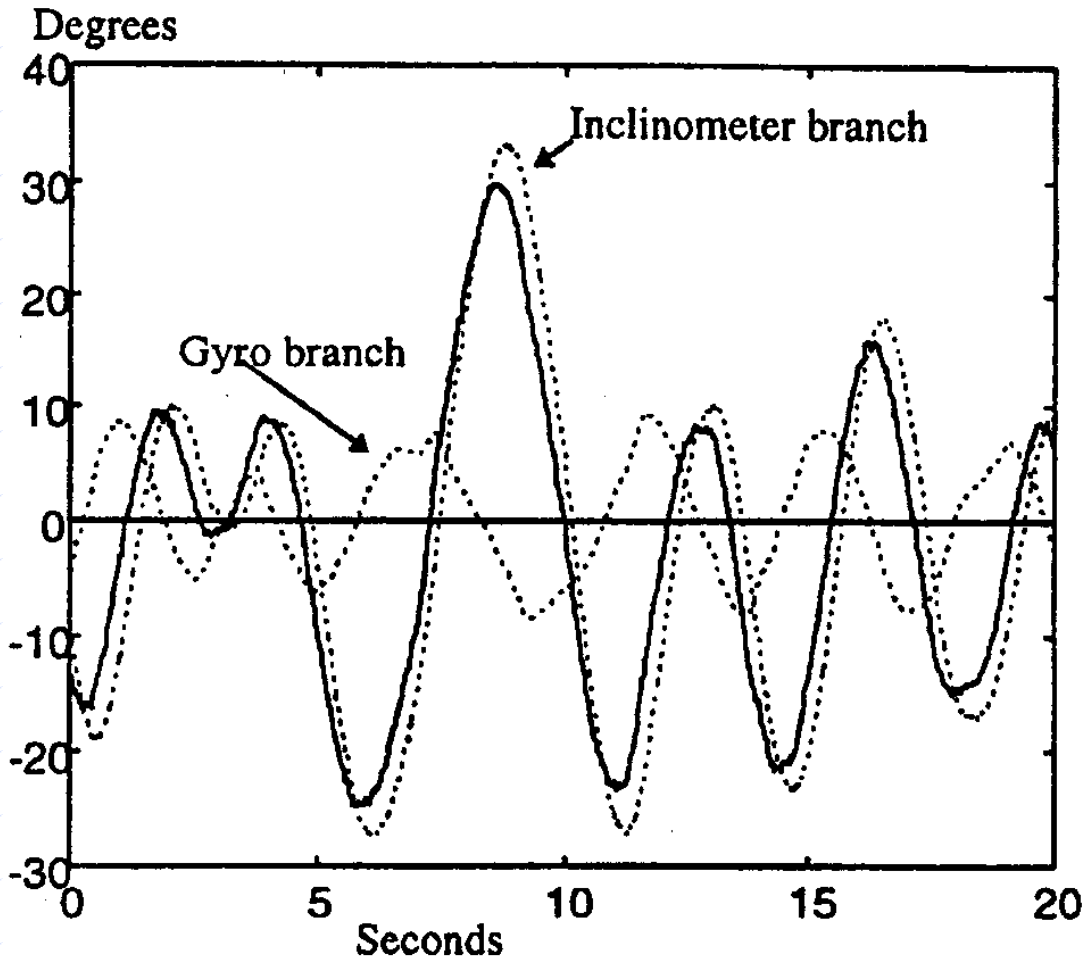


Tilt Sensor

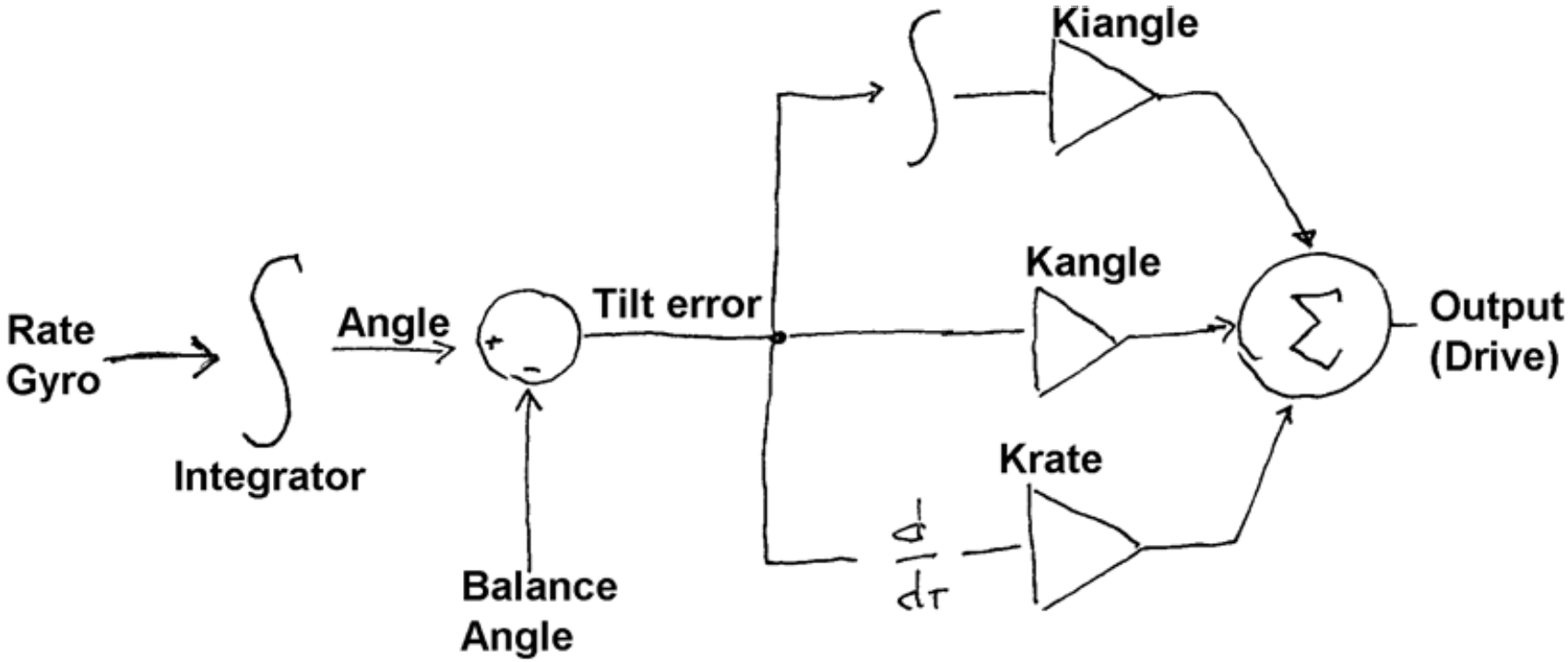
- Complementary filter.
  - Filter out drift in gyro (Hi-pass filter).
  - Add to tilt.
  - Results are fast & drift free



Complementary Filter Results



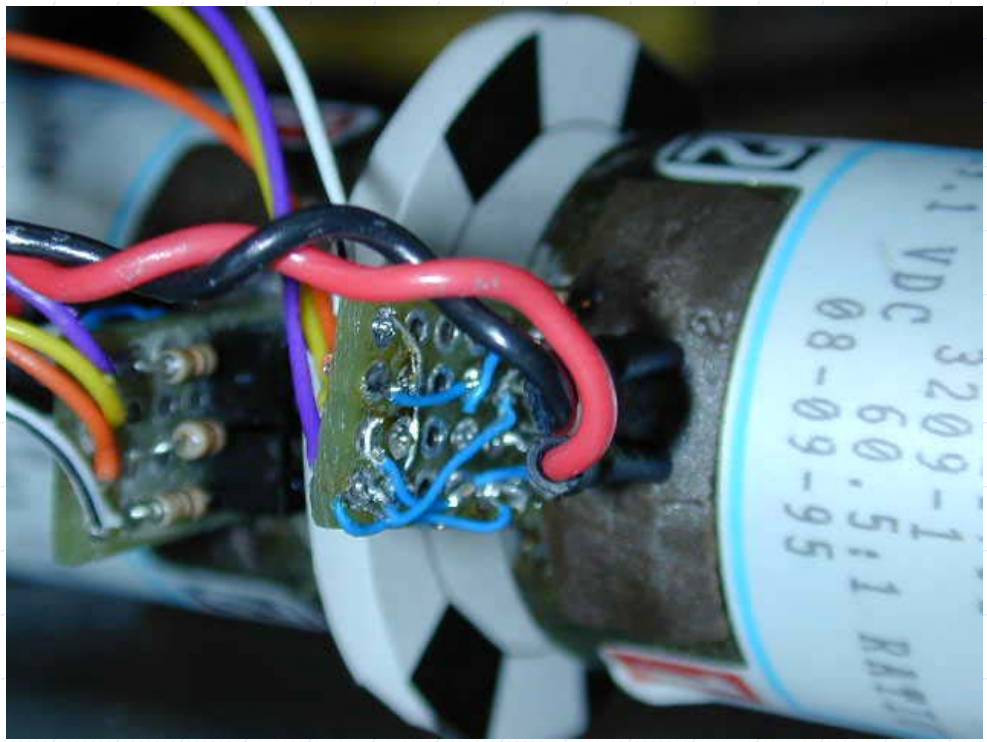
Gyro Balance Equation



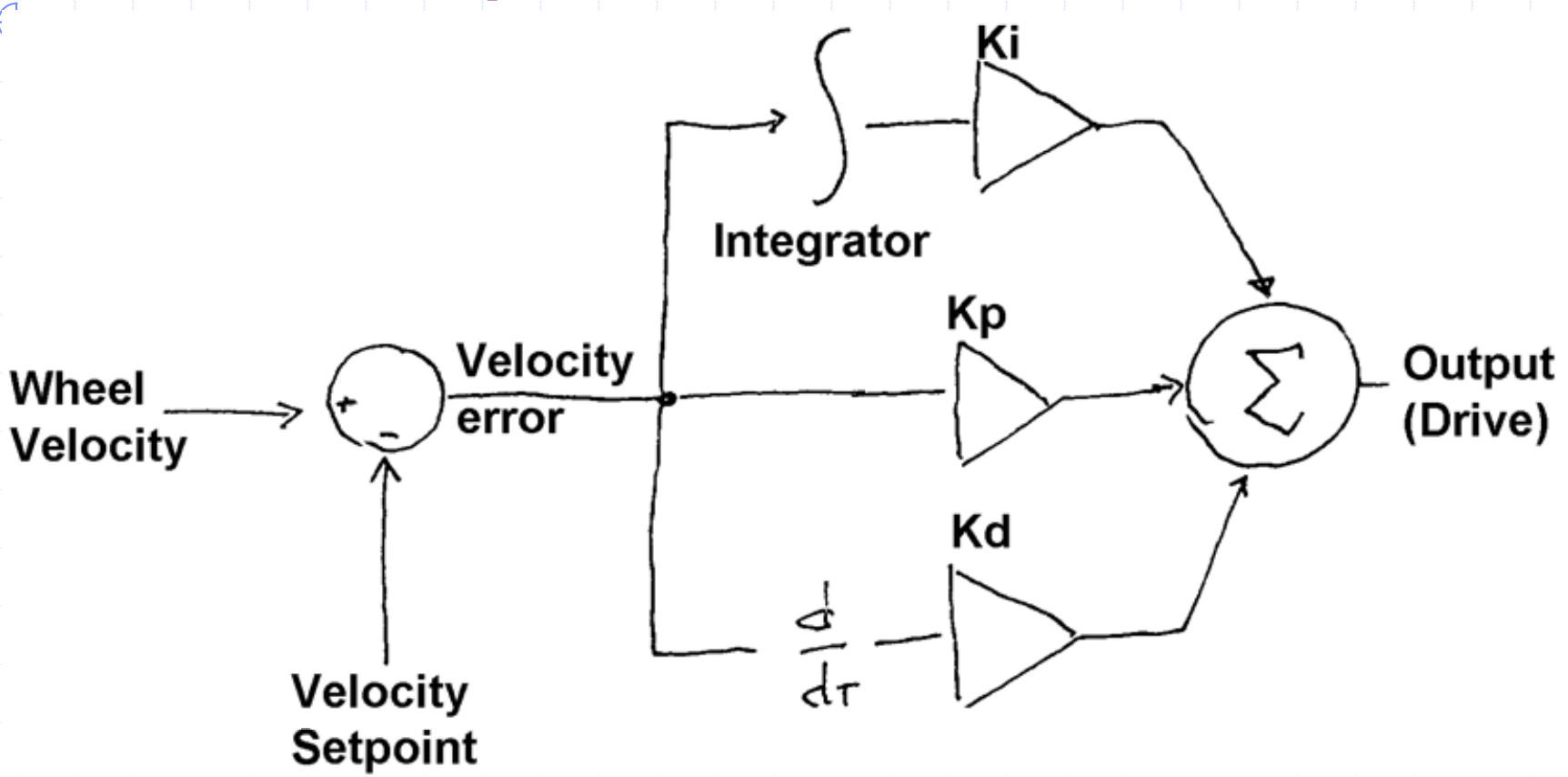
- Classic PID control algorithm (Proportional, Integral, Differential)

Motion Sensor

- Encoders measure position and velocity of wheels.
- Dead reckoning can be derived from encoders and the robots position determined in X, Y and Theta.



Motion Equations



- Classic PID control algorithm

Current Status

- Accelerometer and gyro not integrated.
- Motion control not implemented.
- Navigation disabled.
- Remote control (Radio link) not implemented.

In short, it doesn't do anything interesting yet.

Advantages

- Traverses rough terrain naturally
  - Stairs (with appropriate wheel diameters).
  - Bounces off of obstacles
  - Can roll over jumps
- Balance forces indicate external world
  - Avoidance maneuvers triggered by balance forces.
- Simpler construction, less parts.

Additional reading

- Robots & controls
  - www.barello.net/Robots
  - www.barello.net/Papers/Motion_Control
- Complementary Filters
  - http://www.barello.net/00632450.pdf
- Autonomous Helicopter
  - http://autopilot.sourceforge.net/
  - http://user.cs.tu-berlin.de/~remuss/marvin.html
- Data sheets
  - http://www.systron.com/prodinfo/AQRS.html
  - http://products.analog.com/products/info.asp?product=ADXL202