Unmanned Navigation and user Interface for Aerial Vehicles

Petrou f. Palogos A. Kavoussanos E. Palamas G. Papadourakis G.

Technological Educational Institute Of Crete
Department Of Applied Informatics and Multimedia

Autonomous air vehicle combines sensed heading and spatial coordinates and a user defined mission statement.

Modulated data produce navigation reference signals used to autonomously control the plane.

The system can switch, through remote control, between automatic or manual operating modes while in flight.

Additionally, a highly interactive user interface control serves for both trajectory editing and programming and flying data acquisition.

Experimental data shows that the plane is able to navigate between predefined coordinates and reach target positions.

UAV Design Requirements

- Use and development of UAV for military and civilian applications is rapidly increasing.

- Similar to the manned aircraft the challenge is to develop optimal configurations to produce a high performance aircraft that satisfy the mission requirements.

- UAV systems are ever increasingly becoming important topics for aerospace research and industrial institutions.

- Difficulties in these new concepts are
  - the compromising nature of the missions to be performed, like high or medium altitude surveillance
  - variable environments and many others.

How UAVs Operate

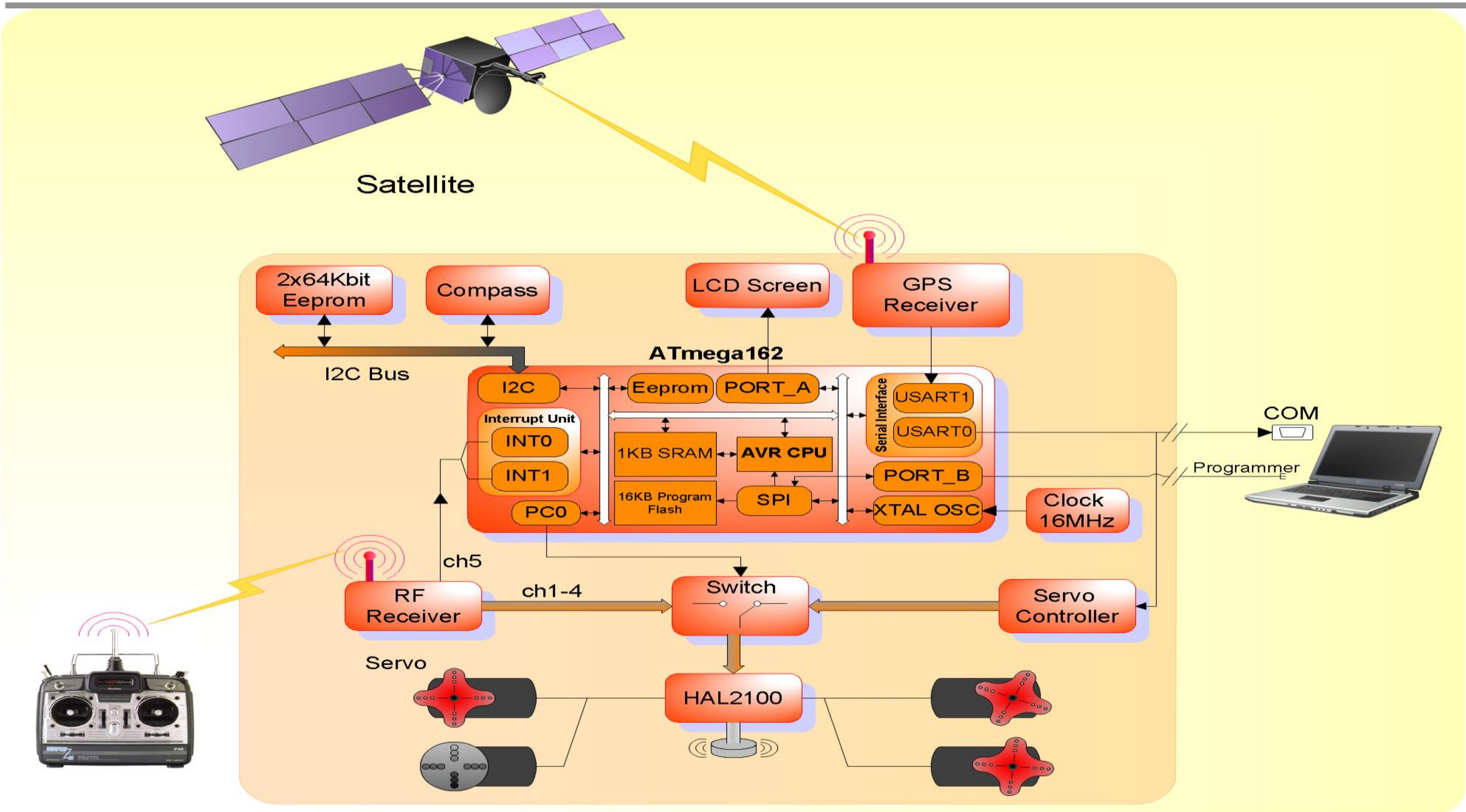
Unmanned Aerial Vehicle, also known as a drone,
an aircraft without a human operator on board

UAVs are flown and navigated by onboard computers
and operated by humans on the ground

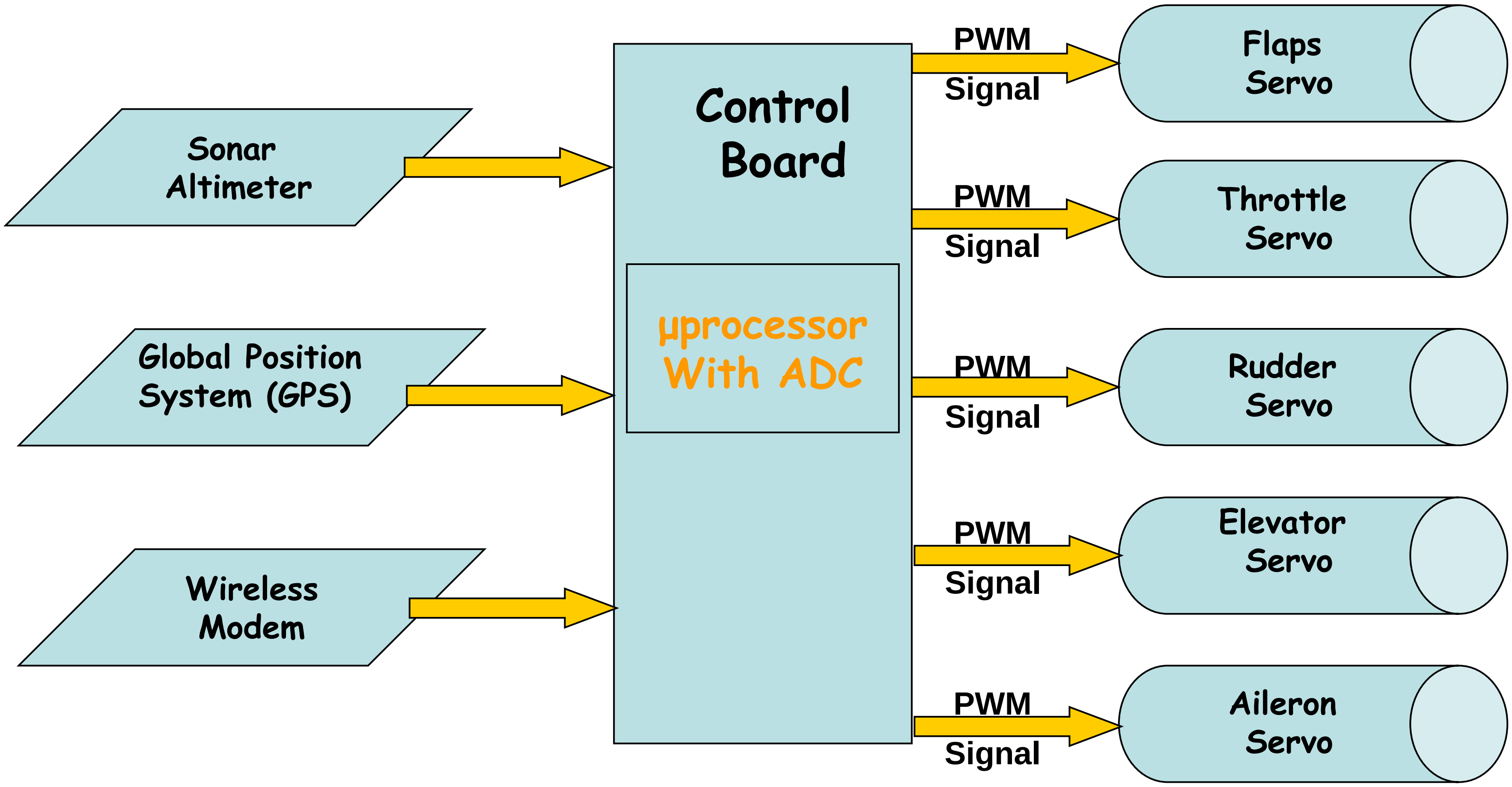
Software code containing the entire mission plan is downloaded
to the UAV's computers before or after it is launched

The operator on the ground does not "fly" the UAV
but can change the mission plan by sending new software
instructions to the computers via radio

General Schematic

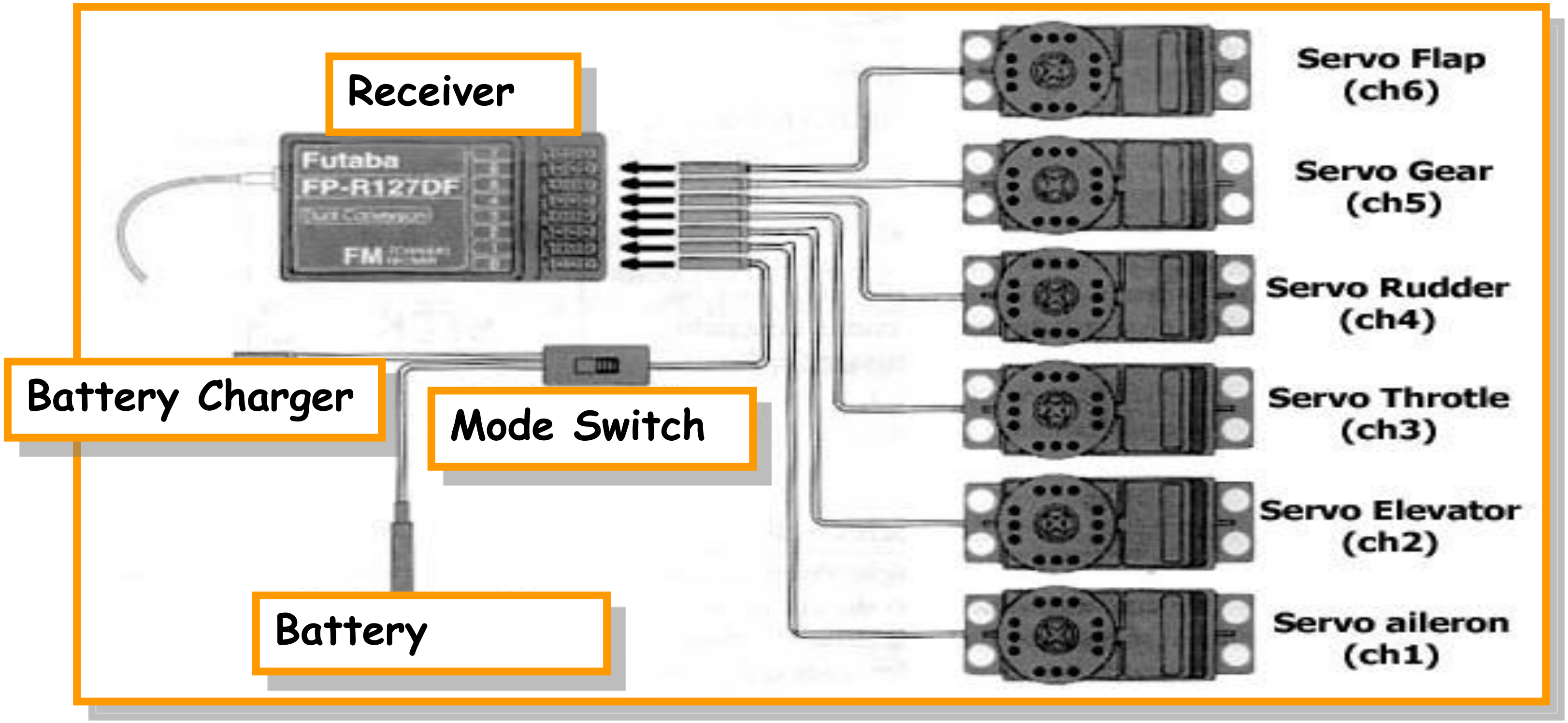


Control Board



Operational Modes

- Autonomous with the aid of autopilot
- Guided from the user (take off, landing, general emergency case)



I2C Protocol

- I2C is a 2-wire, half-duplex, serial bus
- multi-master serial computer bus invented by Philips
- used to attach low-speed peripherals to embedded systems
    - Compass
    - Global Position System receiver
    - Altitude sensor
    - Gyroscope

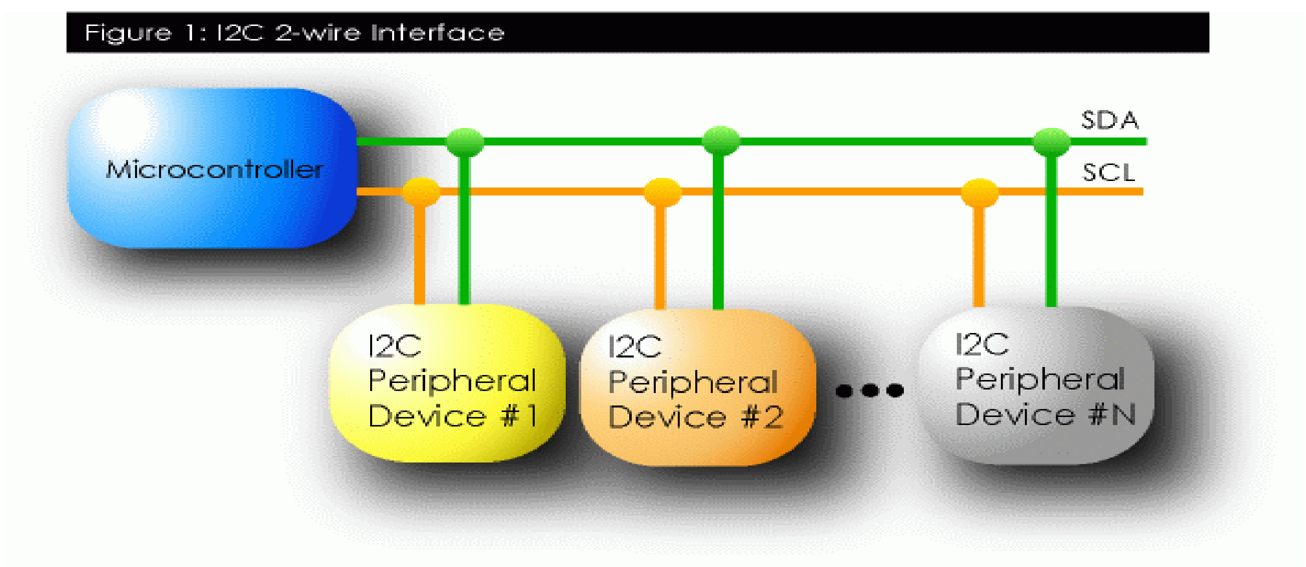
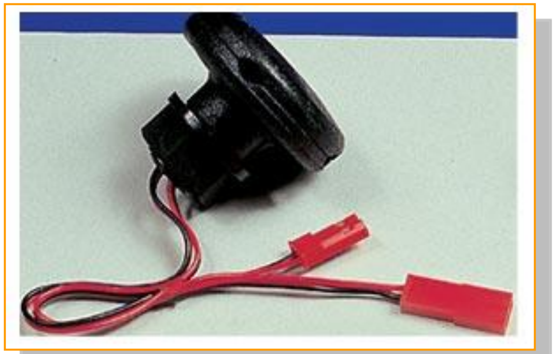


Figure 1: I2C 2-wire Interface

Autopilot HAL 2100

- Horizontal Auto Levelling system
- Safely manoeuvres plane
- optical sensor monitors the attitude 100 times every second
- Integrated microprocessor instructs the servos to return the aircraft to straight and level flight



What is a Kalman filter (1/2)

The Kalman filter is an efficient recursive filter that estimates the state of a dynamic system from a series of incomplete and noisy measurements.

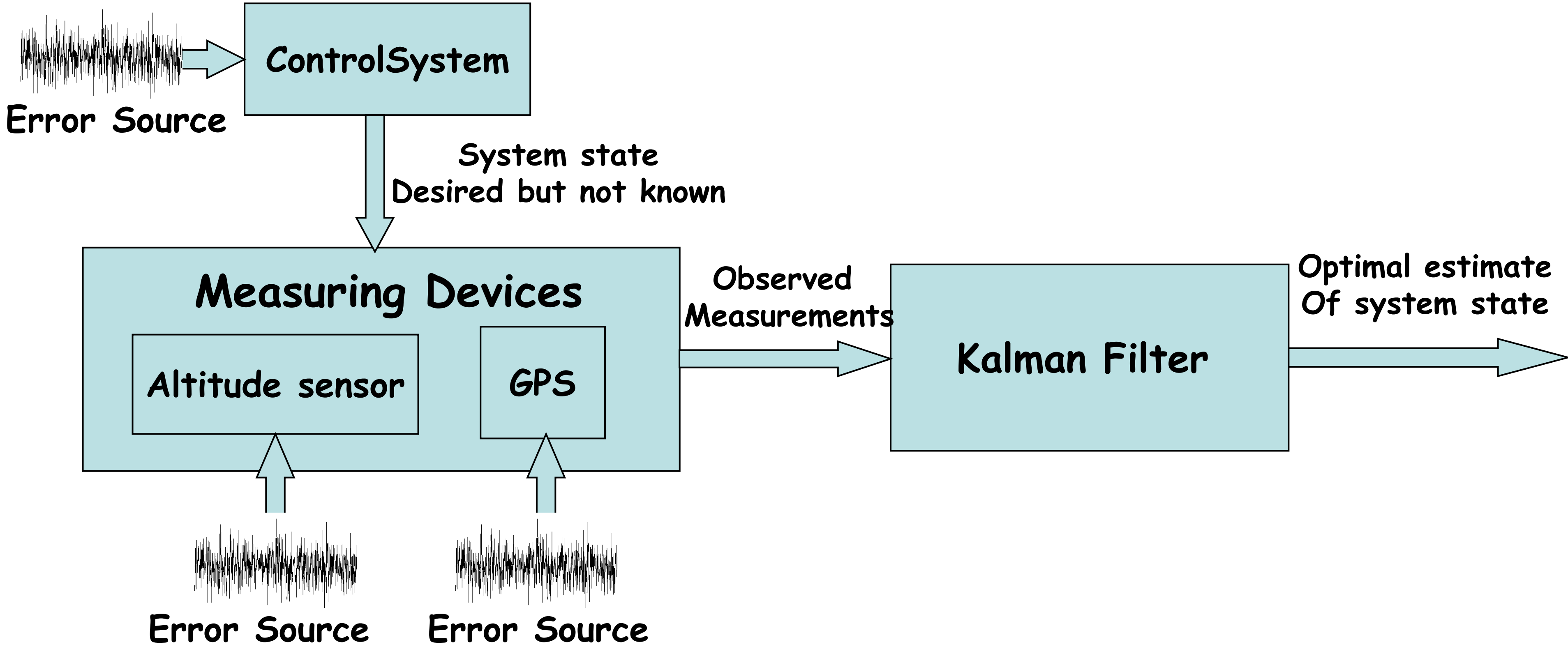
Information regarding location, speed, and acceleration of the plane is measured with a great deal of corruption by noise at any time instant.

Kalman filter exploits the dynamics of the target, which govern its time evolution, to remove the effects of the noise and get a good estimate of the location of the target at:

- *present time (filtering)*
- *at a future time (prediction)*
- *at a time in the past (interpolation or smoothing).*

What is a Kalman filter (2/2)

- Optimal recursive data processing algorithm
- Typical Kalman filter application:



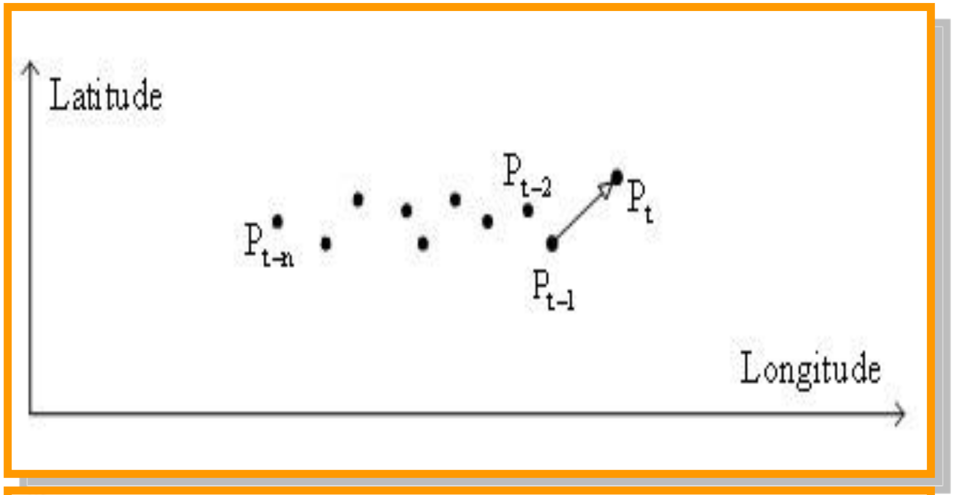
Least Squares Method

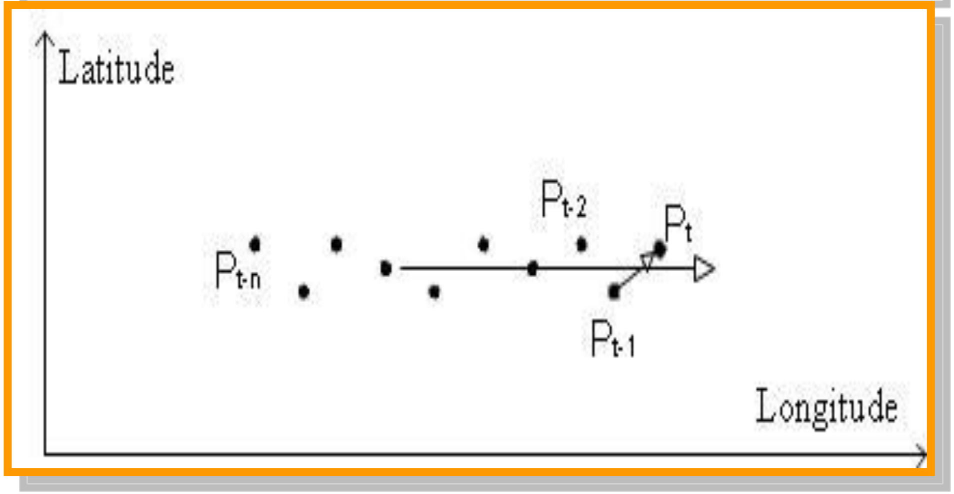
least squares is a method for linear regression that determines the values of unknown quantities in a statistical model by minimizing the sum of the residuals (the difference between the predicted and observed values) squared.

The least-squares approach to regression analysis has been shown to be optimal in the sense that it satisfies the Gauss-Markov theorem.

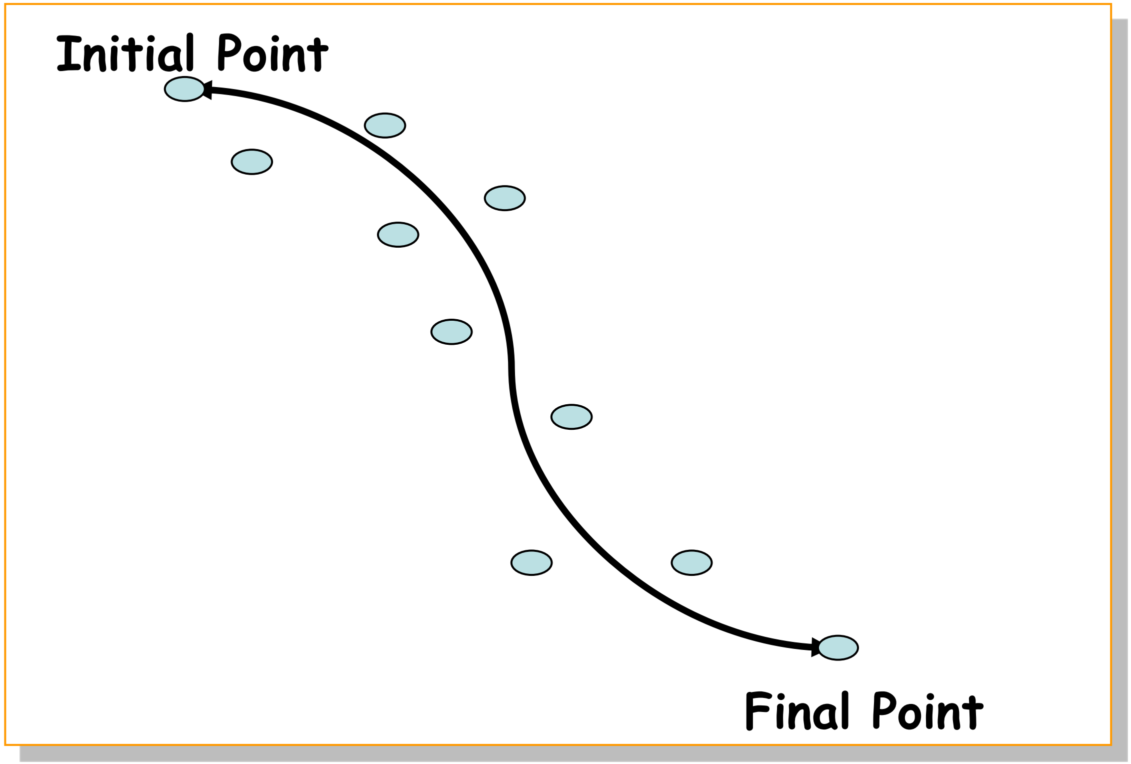
- The objective consists of adjusting a model function to best fit a data set.
- The chosen model function has adjustable parameters

Least squares trajectory planning



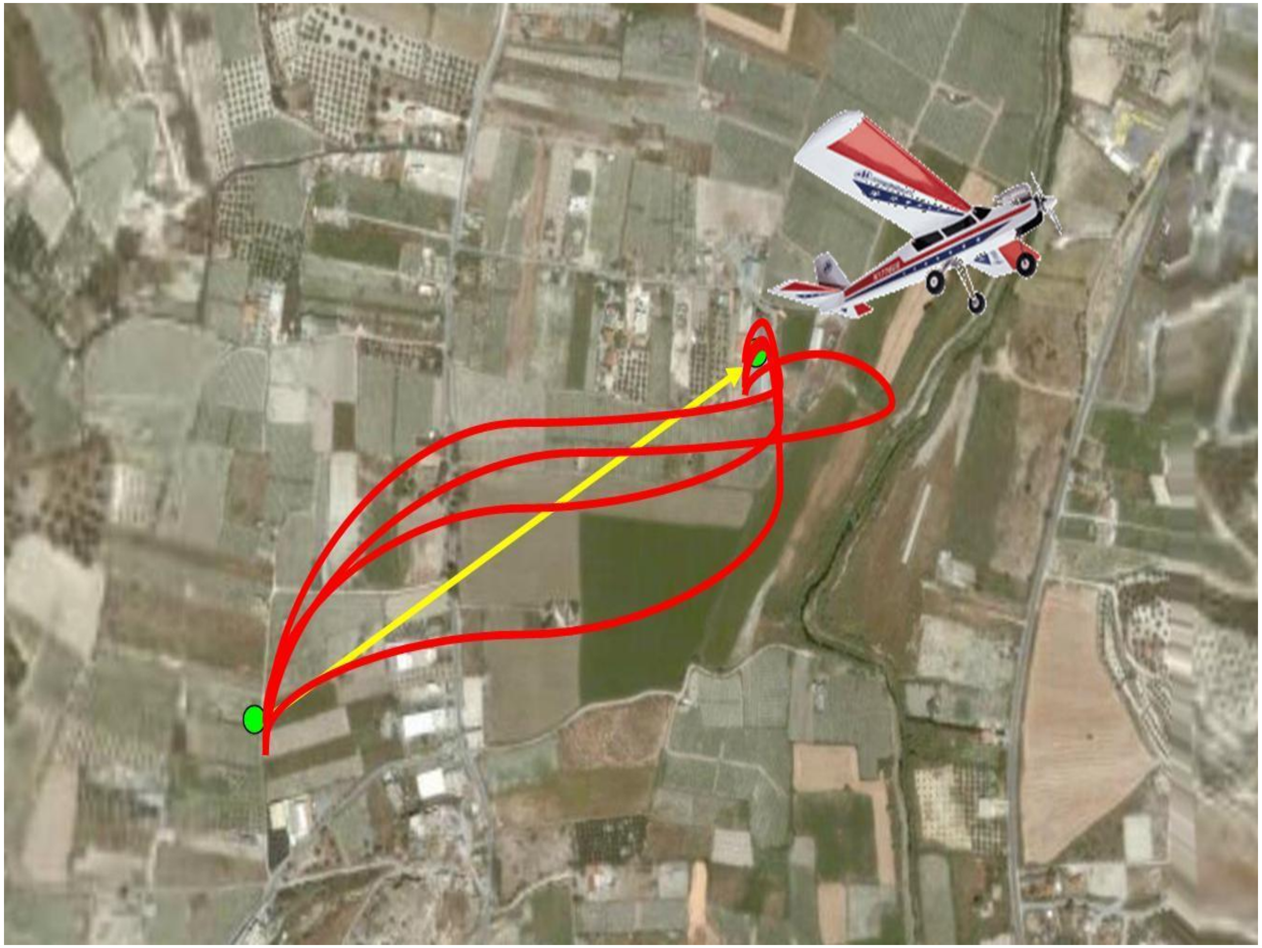


Optimal Route planning

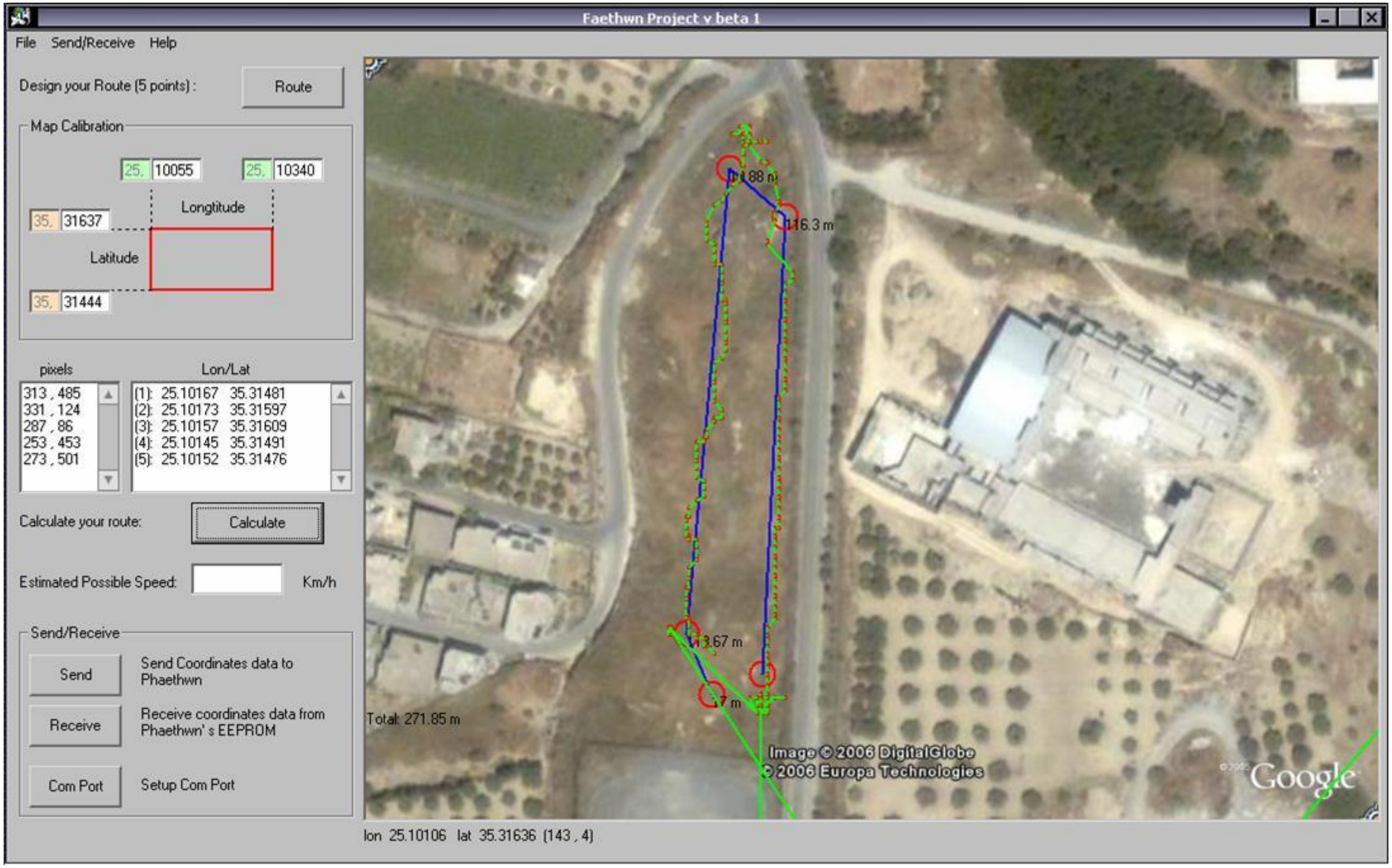


- Find minimum distance route
- Efficiently control speed and acceleration

Different Routes for Different Parameters



Monitoring and Control Software



Conclusions

- Model Plane is able to navigate through predefined positions
- Predictable behaviour for stable conditions like wind speed

But

- Parameters can only be adjusted through trial and error
- Different conditions like wind speed means different behaviour
- Microcontrollers are not very well suited for computations like Kalman filters and Least Squares