Real-Time GPS and AHRS Data Acquisition for use in Synthetic vision flight experiments

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Objective

- Receive data from sensors in real-time and combine them to obtain appropriate outputs to feed the Synthetic Vision System
- Sensors
  - Crossbow AHRS
    - MEMS accelerometers
    - Angular rate sensors
    - Miniature Fluxgate sensors
  - Novatel OEM4 GPS receiver
    - Single element antenna

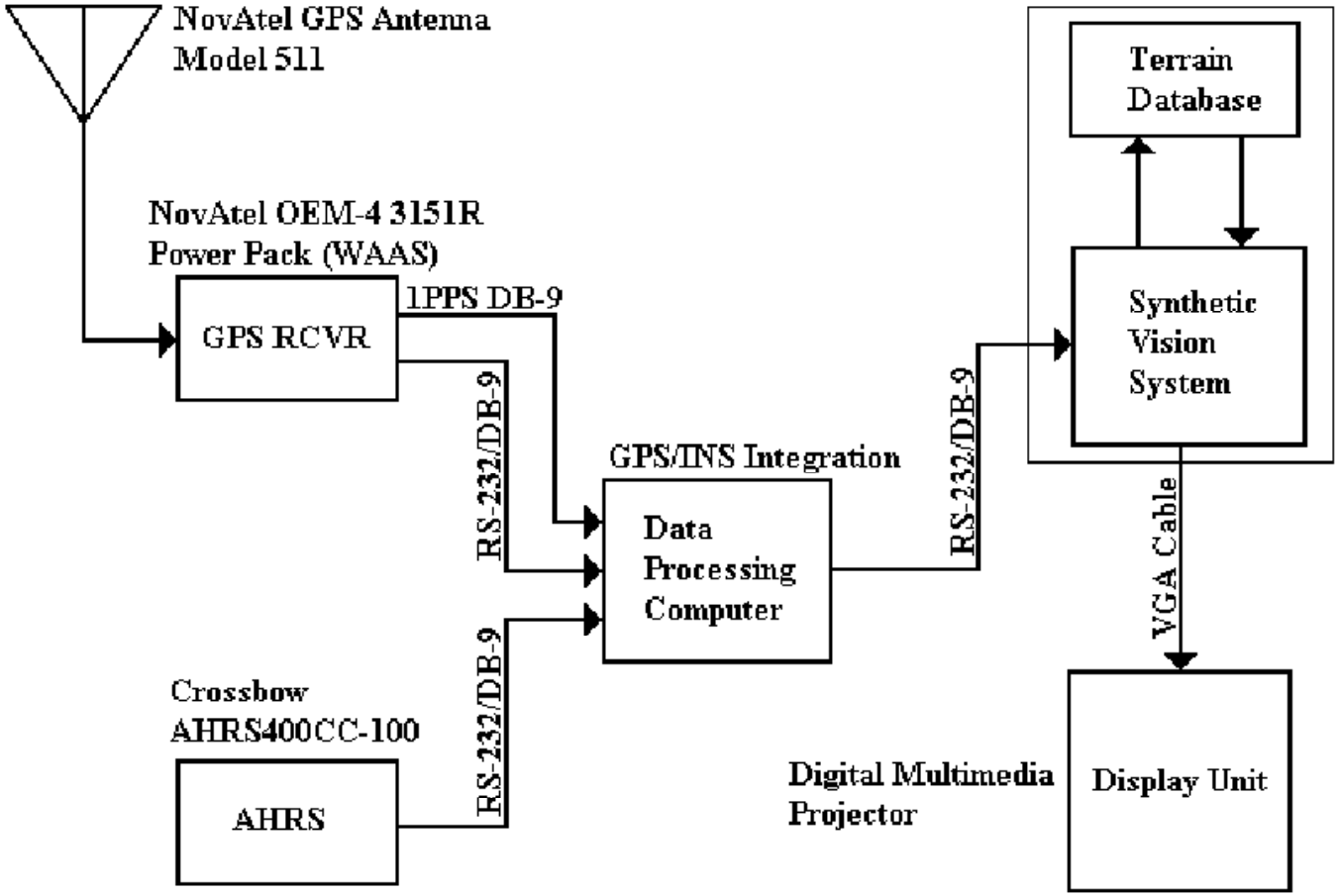
Data Processing Requirements

- Ability to handle high data rates from the sensors in order to capture system dynamics
- Process data in real-time
- Time-tag sensor data
- Interrupt driven system with low context switching overheads
- Environment that supports multiple threads
- Generic data collection utility to ensure compatibility with other systems

Options

- Utilize an RTOS – QNX neutrino
  - Scalable
  - Micro-kernel architecture
  - POSIX compliant
  - High performance memory protection
  - Fast context switching
  - Efficient interrupt handling and multi-threading
- Code developed in C and compatible with C++ modules
- RS-232 Sensor-PC interfaces

Setup


NovAtel GPS Antenna
Model 511
NovAtel OEM-4 3151R
Power Pack (WAAS)
GPS RCVR
1PPS DB-9
RS-232/DB-9
GPS/INS Integration
Data
Processing
Computer
RS-232/DB-9
Terrain
Database
Synthetic
Vision
System
VGA Cable
Crossbow
AHRS400CC-100
AHRS
RS-232/DB-9
Digital Multimedia
Projector
Display Unit

Data format

- The Crossbow AHRS transmits data in binary format.
- The Novatel unit can transmit the GPS data in ASCII and Binary
- ASCII vs. Binary
- GPS and AHRS are setup to communicate with the PC using binary data transfer mode

AHRS Data

- AHRS data modes
  - Angle Mode
  - Scaled Sensor Mode
  - Voltage Mode
- Angle mode (Packet Size: 30 Bytes)
  - Acceleration
  - Attitude
  - Attitude rate
  - Magnetic field
- Above information is provided by the AHRS in digital data packets via the RS-232 (38400 bps, 8, N, 1)

AHRS Data Packet

Byte Number	Data
0	Header (0xff, 8 bits)
1-6	Roll, Pitch and Heading Angles (16 bits, MS Byte first)
7-12	Roll, Pitch and Heading Angular Rates (16 bits, MS Byte first)
13-18	X, Y, Z axis accelerations (16 bits, MS Byte first)
19-24	X, Y, Z axis Magnetic Fields (16 bits, MS Byte first)
25-26	Temp Sensor Voltage (16 bits, MS Byte first)
27-28	Time (16 bits, MS Byte first)
29	Checksum (8 bits)

GPS Data

- Novatel data format is binary (115200 bps, 8, N, 1)
- PC receives two types of GPS Data
  - Position
  - Velocity
- Position and velocity data logs contain the best available positions and velocities computed by the receiver
- Packet Header size: 28 bytes inclusive of 3 Sync bytes
- Variable position and velocity packet rates currently set at 20 Hz

GPS Data Packets

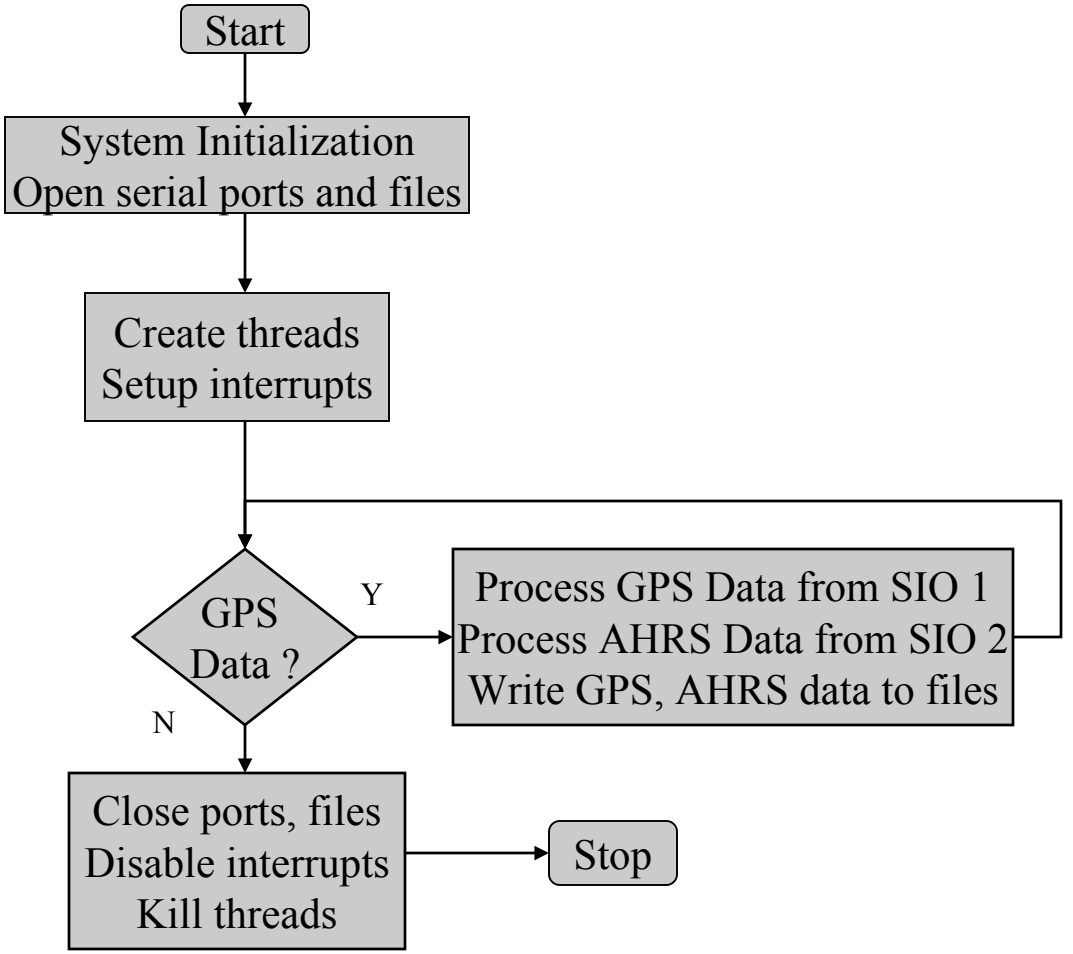
Position

- Packet Size: Header + 72 bytes
- Packet Contents
  - Position in LLH
  - Solution Status
  - Statistics of the position solution
  - Reference station ID
  - Differential age
  - Number of channels tracked
  - 32-bit CRC

Velocity

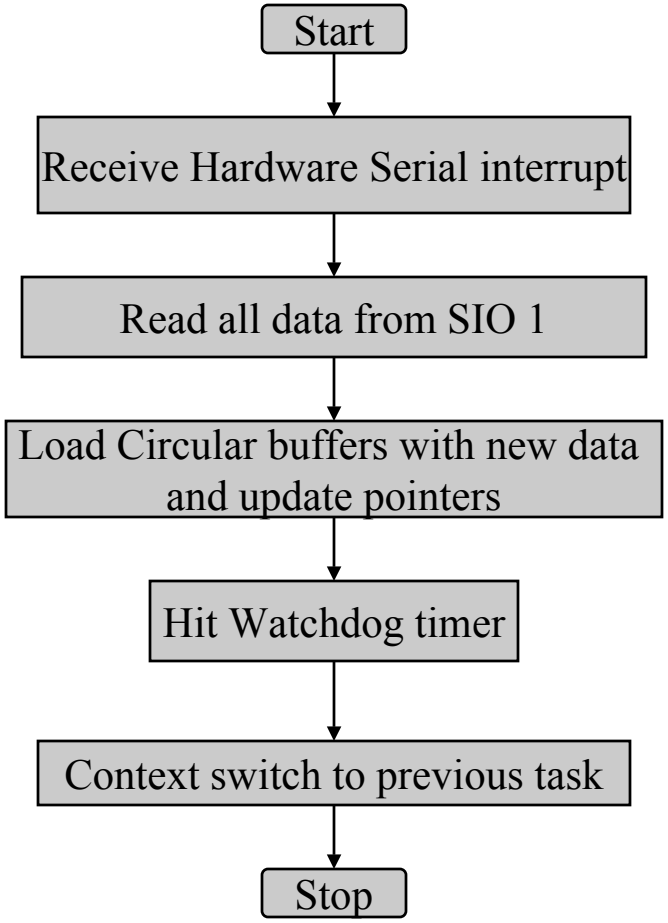
- Packet Size: Header + 44 bytes
- Packet Contents
  - Velocity type
  - Solution status
  - Latency
  - Velocity
  - Vertical Speed
  - 32-bit CRC

Top level flowchart of the real-time code

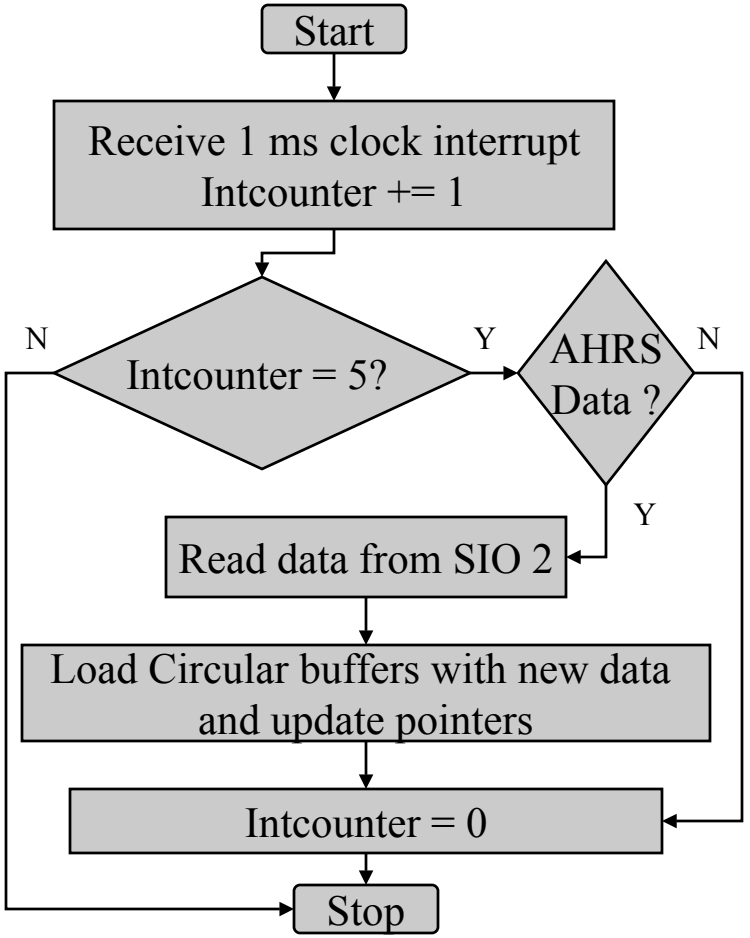


ISR Processing: GPS and AHRS

GPS ISR processing

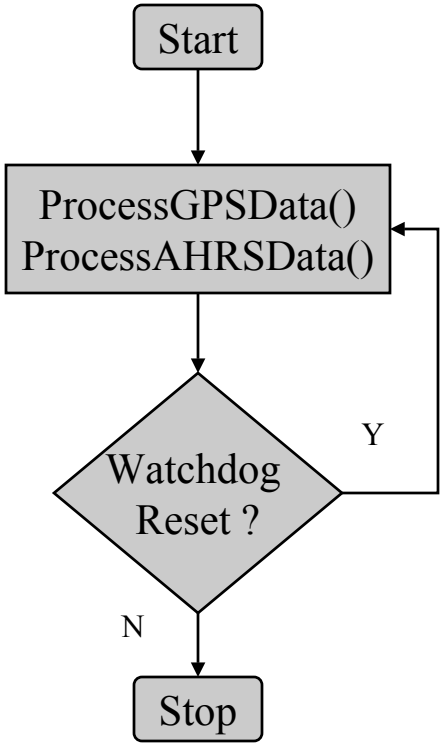


AHRS ISR processing

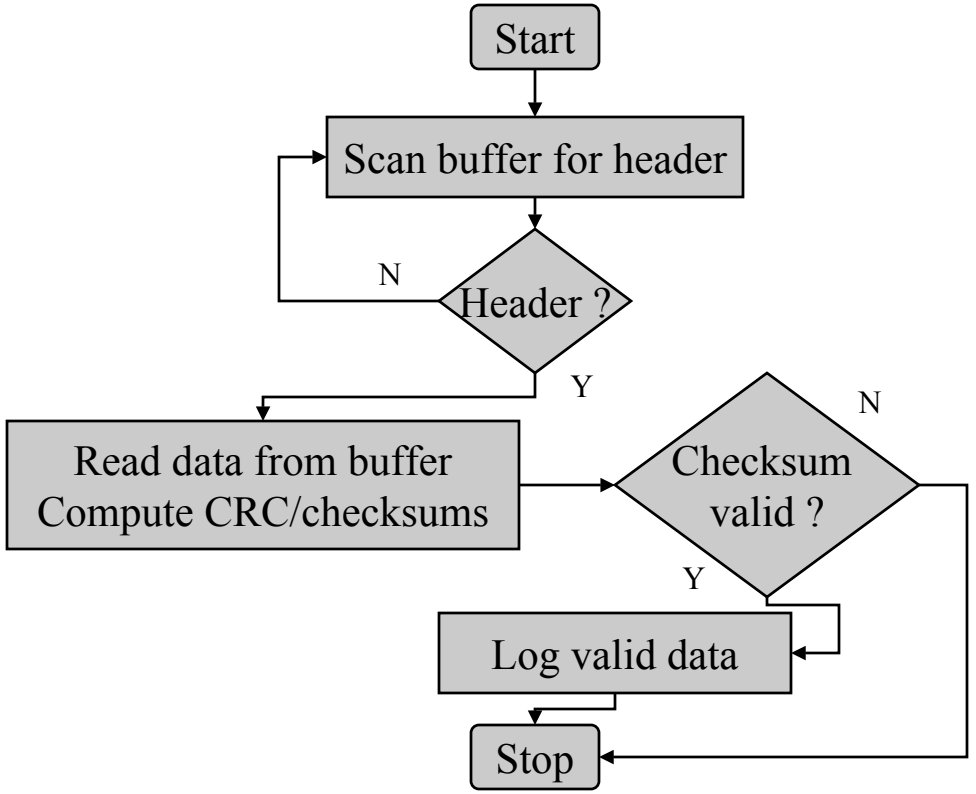


Background processing to decode GPS and AHRS Data packets

Top Level Processing



Generic flow of code for GPS/AHRS data decoding routines



Conclusion

- Successfully implemented real-time utilities to handle multi-sensor inputs in a QNX environment
- Software can successfully handle 60 Hz of AHRS data and 20 Hz GPS (position and velocity) data
- Current implementation can be flight tested to obtain sensor data in real-time for GPS/AHRS integration
- Addition of another serial port will enable the data processing computer to communicate with the Synthetic vision system