The Flight Gear Flight Simulator

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- Uselinux SIG presentation at Usenix 2004, 10:30 July 1 2004

GPL Open Source licensed
Mac, Win32, Mac, Irix, Linux platforms
runs in both 32 bit and 64 bit

http://www.flightgear.org/

Outline

- History of the project
- FlightGear's realism capabilities
  - Relating these to the modular subsystems
- Explain the network interface
  - And the python wrapper for it
- Discuss the challenges and shortcomings
  - Limitations for practical deployment

What is FlightGear ?

- A flight simulation project
  - trying to simulate reality - not simply play
- Our approach is
  - Open source (GPL) - Free - as in speech and as in beer
  - Portable
  - Platform neutral
  - Advanced algorithms - good models, not just guesses
  - Inclusive - not just software engineers
  - Multidisciplinary - technical and non-tech skills
- Beginners welcome ...

A worldwide developer community

- The credits file has 89 names and is still growing ...
- Some of their locations are shown on this map:

FlightGear - Key Developments

1996 April, Project started by David Murr
... Intended to be usable on 486 class processors and faster
1997 July, Curt Olson made a multiplatform release
... Merging existing contributions to a consistent usable form
1998 August, Curt creates the official site flightgear.org
1999 May, Added PLIB for better graphics portability
2000 February, Tony's LaRCSim Cessna 172 is default aircraft
2000 May, Wet compass, radio navigation, magnetic variation
2001 July, generic joystick support, instrument audio effects
2002 February, JSBSim is default, YASim (another FDM) added
2002 September, realistic Wright Flyer aircraft completed
2002 December, Voice ATIS, gyro instruments, some failures
2003 October, helicopter support, improve default scenery

- More detail at http://www.flightgear.org/version.html

Realistic 3D aircraft and scenery

What does FlightGear currently offer ?

- The pilot's view of the cockpit and of the 3D scenery
- Dozens of realistic aircraft models
- World wide terrain, airports, electronic navigation, etc
- A modular architecture for ease of enhancement
- Stands on the shoulders of many other open source projects
  - OpenGL/Mesa, PLIB, GLU/GLUT/SDL, OpenAL, SimGear,
  - JSBSim, LaRCSim, YASim, TerraGear, OpenGC, Atlas, etc ...

Standard landing screenshot 2004

Accurately Impairing Ease of Use - Selectively

- Real aircraft should be simple and easy to fly
  - They're complex machines - many things can go wrong
  - Subtle interactions can distract and confuse the pilot
  - FlightGear aims to be equally difficult to fly
  - Neither more, nor less, just like the real thing
- It takes a lot more code to make something behave badly
  - And it is harder to make the source look neat
- But the point is to be an immersive experience
  - Any pilot should intuitively interact with the cockpit
  - Ease of use is critical, with accelerators etc etc

Simulating the Aircraft

- The aerodynamic simulation is only one part
  - Of the whole environment being simulated
  - Its performance is critical to the user's experience
  - Errors in Flight Dynamics Model (FDM) are distracting
- Other simulator components such as the autopilot
  - Are designed to expect a realistic aircraft
  - May respond incorrectly as a result of FDM errors
  - Provide additional pilot distractions
- Can ruin the user's immersive experience
- The FDM is created as an object abstraction
  - Allows multiple FDMs to be installed
  - Permits R&D use and future expansion

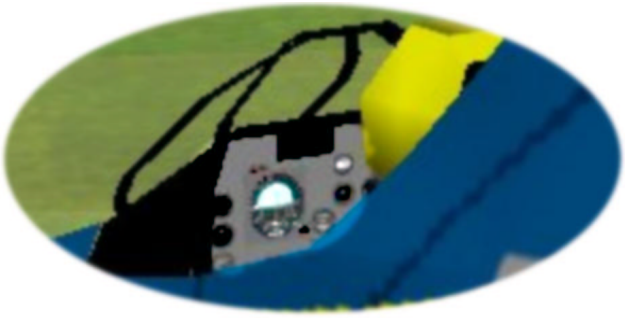
Simulating - Flight Dynamics Model

- LaRCsim, models a Cessna 172 or Navion
  - Dedicated C source with coefficients hard coded
  - Supports all normal flight maneuvers
- University of Illinois, parametric derivative
  - Simplified the models for cruise flight regimes
  - A configuration file is loaded at simulation start
  - Supports many different light aircraft choices
- JSBSim, completely parametric FDM
  - All the information is retrieved from XML format files
  - Can run independently of a full environmental sim
  - As of this year, supports the Cessna 172 fairly well and
  - The X-15 (a hypersonic rocket propelled research vehicle)

XML appearing everywhere ?

- Most configuration files are XML
  - The engine models,
  - The instrument panel layouts, instrument designs,
  - The head up display layout,
  - The user preferences and the saved state
- The real benefit of using XML here ?
  - For people with no software development background
  - Pilots, instructors, maintenance techs, researchers
  - They can easily and effectively contribute
  - All have in-depth technical knowledge of value
  - How an aircraft and hence the simulator should behave

Realistic interior of 3D models - instruments



- Those instruments move ...

Simulator Structure - Properties

- Core is directly interacting objects
  - High level state is also generalized out of them
- Property database - XML scripting is new
  - Relates a hierarchical name: /position/latitude
  - To an object with getter and setter methods
  - Ideal for user interface needs and saved state
  - Parametric graphics elements, configuration files
- Properties are network accessible
  - runfgfs --telnet=5555
  - telnet localhost 5555
  - Especially useful for Flight Instructor activities
  - Independent programs can interact with the simulation

Python Class - Method access to properties

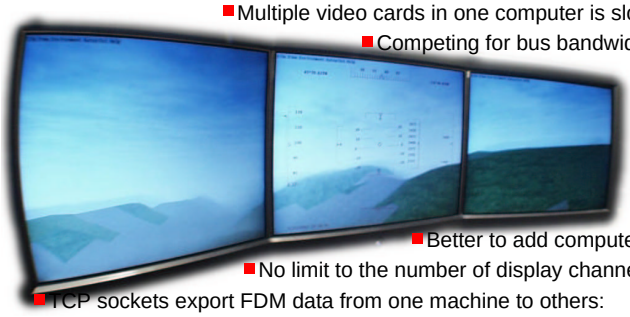
- class FlightGear
  - Properties accessed using a dictionary style interface
  - Allows the utility author to ignore how it all works
  - This is key - extensions are written by non-programmers
- For example:
  - fg = FlightGear('myhost', 5500)
  - fg['/controls/gear/brake-parking'] = 1
  - heading = fg['/orientation/heading-deg']
- def __getitem__(self,key)
  - Get a FlightGear property value by its full path
  - Where possible, converted to the equivalent Python type
- def __setitem__(self, key, value)
  - Set a FlightGear property, silent type cast to string
- def quit(self)

Why is networking important ?

- Offers remote access into the running simulation
- Enables an instructor to adjust the pilot's settings
- Permits integration with existing simulation modules
- Multiple computers share the 3D rendering workload

Multiple displays using several computers

- Pilots expect a wide view - aircraft have big windscreens
- Multiple video cards in one computer is slow
- Competing for bus bandwidth



- Better to add computers
- No limit to the number of display channels
- TCP sockets export FDM data from one machine to others:
- --native=socket,out,60,s1,5500,udp --view-offset=-50

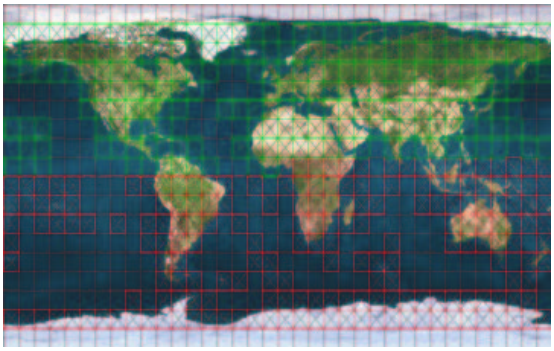
Glass cockpit - a separate project

- http://www.opengc.org

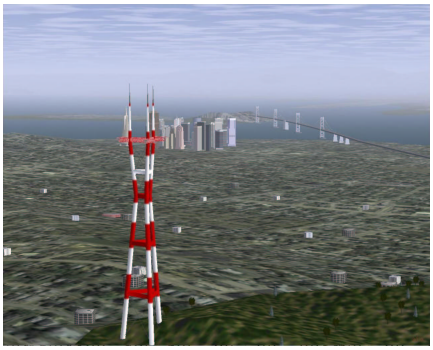
TerraGear - Storage size

- Clearly a synthetic image, but sufficient
  - Navigate by pilotage - comparing view to a chart
- Compact, about one kilobyte per square kilometer
  - Necessary, since about 10000 sq km may be in view
- Stored in a 4 level hierarchy, each 10-100 smaller
  - One planet, currently only the Earth
  - 10 deg x 10 deg rectangle
  - 1 deg x 1 deg, approx 100 km x 60 km (5 megabytes)
  - A rectangular tile of 100 km^2 approximately
- Recently using 90m SRTM terrain data Asia, Europe, Africa
  - Added roads, railroads and built up areas

TerraGear - the world - really



Default scenery in 2004



Mismatched Charts - Atlas

- Public domain data is generally of reduced quality
  - or out of date, or selective, or local coverage, etc
- The scenery generated from that data is actually wrong
  - Compared to the real world out there
- Synthetic charts - Atlas project
  - Automatic translation of TerraGear files
  - Generates usable aviation style charts
  - Inaccurate compared to the real world
  - Therefore useless for flight in an aircraft
- The Atlas application is for browsing
  - Display aircraft current location on moving map
  - Most small aircraft do not have moving map GPS
  - Invaluable to the flight instructor

Synthetic chart - example

San Francisco Bay Area

Weather - both Visual and Aerodynamic

- FlightGear supports many aspects
  - Air temperature is invisible, but affects the aircraft
  - Clouds and smog are visible, but no effect on aircraft
  - Rain is both visible and affects the aircraft somewhat
  - Turbulence is a multifaceted and complex phenomenon
- Can vary by location and height as well as time
  - User has to explain the desired configuration ...
- A single set of conditions
  - On the command line, applied to the entire planet
- Tweak through property database
  - Instructor might adjust for weather decision making
  - Such adjustments use the network interface to properties
- Monitor current weather conditions
  - Uses the closest station, but leads to sudden transitions
  - Useful when real conditions are too dangerous for flight

Cloud layers - Textures with Alpha

Simulator Applications

- A wide range of people interested
  - Building a realistic home simulator out old airplane parts
  - Simply having a viable alternative to commercial sims
  - Icing research platform at Smart Icing Systems Project
  - Control algorithms for an autonomous aerial vehicle
  - Retrofit older sim hardware with FGFS based software
  - Renew an Agwagon single seat, single engine simulator
  - Image generator for eval of ski-jump launch
    - and arrested recovery from an aircraft carrier
  - Scenery and out-the-window view for Genesis 3000 sim
  - Airport familiarization to avoid runway incursions
- ... and many more

Flight Training

- Could also be helpful when learning to fly
- Flight training is carefully regulated by government
  - To ensure that aircraft generally stay in the sky
  - Until their pilot intends for them to come down safely
  - There are real concerns,
  - before authorities can approve a system
- What does the U.S. government want ?
  - Any pilot can sit down and immediately use it
  - It isn't dangerously different or deceptively easy
  - The instructor can specify the flight environment
- Instructor configurability ?

Flight Training - FGATD

- Flight Gear Avation Training Device
  - http://fgatd.sourceforge.net
  - Goal is to implement requirements to achieve approval
  - Most of the work is documentation and testing
  - Actual simulation is a minor part of the whole
  - Finding sources of suitable controls is a challenge
- Project effectively stalled
  - Commercial FGFS derivatives making more progress

A future Flight Training Device (FTD)

- This may become a certified product for flight training!

Portability between Operating Systems

- Portable across operating systems (Mac, IRIX, etc)
  - For sound
  - 3D graphics / OpenGL
  - menus / configuration
  - joystick / mouse / yoke
  - keyboard scan
- Implementation may be equivalent, yet very different
- The PLIB project offers a simple gaming API
  - http://plib.sourceforge.net
- The OpenAL project abstracts directional audio
  - http://www.openal.org

Installation / download

- Generally, the Windows binaries are portable
  - This is critical for most Win32 users
  - Few of them have developer tools installed
- Packaged by most Linux distributors
  - Linux systems are very similar
  - Compared to Windows, MacOS and Irix, etc
  - Most problems affect PLIB first
  - When PLIB runs, FlightGear is generally ok
- With joysticks, for example:
  - Two ioctl()s, /dev/js0 or /dev/input/js0
  - Devices detected early and not consistently numbered

Examples of recent development work

- Virtual GPS for third party software and peripherals
  - eg FlightMaster and CoPilot for the palm pilot
- Getting new hardware working - eg joysticks
- Bringing up FlightGear on AMD64 - mostly OpenGL
- Clickable 3d instrumentation - a clean API
- Dedicated visual channels
- DME bias - mismatch between data and real world
- King air cockpit progress
- MD11 performance notes - corrections
- Multiplayer doesn't work properly
- New scenery rebuild - too many radio towers
- Twilight and dusk lighting - enhanced realism

Conclusions

- FlightGear is a simple Open Source project
  - Builds on many existing projects
  - In the community tradition
- Due to the subject it addresses
  - It has many issues and concerns
  - Are raised that rarely inconvenience other projects
- These elements are providing the exciting challenges
  - And variety of associated activities
  - Enjoyed by the developers
- Thank you for your interest.
  - Questions ?

www.flightgear.org