CS A490
Digital Media and Interactive Systems

Lecture 1 - Introduction
Sam Siewert

**UC Berkeley** – National Research University, *Philosophy/Physics*

**University of Notre Dame, BS** - Private, *Aerospace/Mechanical*

**Johnson Space Center, U. of Houston** – UHCL *Computer Engineering*, National R&D Center, Mission Control Center

**U. of Colorado, Boulder, MS/PhD** – Growing Research University, Gov’t Labs, Start-Ups, *Computer Science*

Interdisciplinary Teaching & Research Aerospace/Mechanical, Computer Science, Computer Engineering

CU Boulder Senior Instructor, Adjunct Professor

CTO, Architect, Developer/Engineer

© Sam Siewert
Related Industry Background

General Experience (~24 Years in Embedded and Scalable Systems)
- Presently Assistant Professor UAA and Adjunct CU-Boulder
- Intel Architecture Group (Atom, Scalable Cloud Solutions)
- CTO at Atrato Inc., a Digital Media Storage Start-up
- Consulting with Numerous Digital Media Firms
- 12 Years NASA JSC, NASA JPL / CU, NASA JPL / Ball Aerospace
- 12 Years Commercial Telecomm, Storage/Networks, Embedded, Digital Video

Machine Vision
- Spitzer Space Telescope – Sky-scan Mosaics, Super-resolution, Peak-Up
- Optical Navigation – JPL
- Robotics at CU-Boulder

Computer Graphics
- Integrated Graphics and Digital Video (UAV Research)
- GIS and Telemetry Video Overlay

Digital Media
- Real-Time Digital Video Frame Transformation (1080p, 60Hz), Color Enhancement
- Commercial Contracts
REQUIRED TEXT -

OPTIONAL TEXT -
http://shop.oreilly.com/product/9780596516130.do
Scalable Linux Systems…

- From Game Consoles to Super-Computing
  - PS3
  - Blue Gene
  - GPGPU
  - Tianhe-1 Pflop

- From Android Mobiles to GIS and Digital Video Services
  - NETFLIX

- Huge Value in Open Source Drivers, Tools, and Applications – Speeds Up Time to Market

- Focus on Leveraging Linux for Desktop and Embedded Systems for Machine Vision and Graphics

Digital Media Systems

Embedded Media Devices
- Set-Top Boxes, Smart-Phones, Tablets (Linux, Android)
- Mobile Media Systems: Readers, Notebooks, DVD Players, iPods, etc.
- Digital Camera Systems (SD, HD, HD-SDI, 2K, 4K, 6K)
  - Resolutions/Formats -
- Game Consoles: X-box, PS3, Etc.
- Gesture Recognition, Augmented Reality
- SD, HD Cameras and Interfaces: Composite, S-Video, Component, DVI, HDMI

Scalable Digital Media Server Systems (Head End)
- Post Production for Digital Cinema, TV, Web
  - 2K, 4K, 6K Streams from Digital Cameras
  - Frame/Color Editing, CGI (Computer Generated Imagery), Soundtrack, Write to Distribution Media
- Digital Cinema: HD Digital Projectors, 3D Digital Projectors
- Closed Circuit Security Systems: Multi-Camera NTSC/HD
Digital Media Focus

Scalable Post Production Pipelines
- Multi-core Threading with POSIX Threads (CPU scaling)
- I/O Scheduling and Tuning (Disk bottlenecks and Capacity Scale)

Real-time HD Frame Transformations
- Color Transformations, Edge Enhancement
- Integrated Graphics & Video (Interactive TV)
- Green Screen Replacement, Video Morphing
- Segmentation, Recognition, Tagging
- Post-Capture Focusing (Demonstrated at CES)
Linux System Options

- Virtual-Box Ubuntu Installation - RECOMMENDED

- Transformer Ubuntu 12.04 LTS Account in CPAL - RECOMMENDED

- Native Linux Installation – Ubuntu - ADVANCED
  - ffmpeg
  - GLUT
Linux Embedded Lab

Beagle xM with Angstrom or Ubuntu Linux
- Logitech C200 Camera
- TI-OMAP DSP, ARM Assembly and C/C++ Programming

Ubuntu Linux desktop on Beagle xM

Beagle xM – beagle.org
Administrivia

**Introductions**
- Instructor (Office Hours) - [http://www.cse.uaa.alaska.edu/~ssiewert/Schedule-Fall-2013.pdf](http://www.cse.uaa.alaska.edu/~ssiewert/Schedule-Fall-2013.pdf)
- Students (Introductions)

**UAA Blackboard**
- [http://www.uaa.alaska.edu/classes/](http://www.uaa.alaska.edu/classes/)

**Course Information**
- Digital Media Primer – Yue-Ling Wong
- E-mail list (please sign up on sheet being passed around)
- Lecture Notes and Labs on UAA Blackboard System (please do not read more than one week ahead)
- Digital Media Terminology – QUIZ

**Personal Lab – You MUST Have VB Linux and/or Transformer Native Linux Account**
- Either using your own Laptop for VB-Linux/ Native
- Or Using CPAL for Mobile and Scalable Linux Systems

**UAA CPAL** - [http://www.cse.uaa.alaska.edu/~ssiewert/cpal.html](http://www.cse.uaa.alaska.edu/~ssiewert/cpal.html)
Final Project!

You will Produce your Own Short DVD (Movie)
- DVD Plus Write-Up
- Code, Methods to Produce, and Design
- Using ffmpeg to Encode SD/HD Digital Video from Frames you have Modified or Rendered
- At least 60 Seconds in Length at 30Hz, So 1800 frames
- Original Creative Work Using CG and Digital Video Processing Methods Learned in Class

OR Build an Interactive System
- HTML5 - http://www.w3schools.com/html/html5_intro.asp
Many Real-Time and Interactive Systems

- Real Time – Must Respond to Requests for Service by a Deadline relative to request
  - Failure to Respond Prior to Deadline Results in a System Failure
  - Request Rate for Service Driven by Real-World Events
  - Controls Processes and Delivers Deadline Driven Services

- Many Hard RT (Embedded) Apps: Anti-Lock Braking, Aircraft Flight Control, Robotic Systems

- Many Soft Real-Time or Interactive Apps
  - Streaming Media (On-Demand), Interactive Systems (Games, WebApps, GUIs)
  - Post Production
  - Digital Broadcast

Hard Real-Time

Soft Real-Time

© Sam Siewert
Real-Time Digital Media Systems

Embedded Media Devices

- Set-Top Boxes (Linux, VxWorks)
- Mobile Media Systems: Smart Phones, Tablet Computing, (Kindle) Readers, Notebooks, DVD Players, iPODs, etc.
- Digital Camera Systems (SD, HD, HD-SDI, 2K, 4K, 6K)
  - Consumer/Pro-sumer Digital Media
- Game Consoles: X-box, PS3, Wii, Nintendo
- Gesture Recognition, Augmented Reality
- SD, HD Cameras and Interfaces: Composite, S-Video, Component, DVI, HDMI
- More to Come?, No Doubt

Scalable Digital Media Server Systems (Head End)

- Post Production for Digital Cinema, TV, Web
  - 2K, 4K, 6K Streams from Digital Cameras
  - Frame/Color Editing, CGI (Computer Generated Imagery), Soundtrack, Write to Distribution Media
- Digital Cable Head-Ends: Server 10K+ Customers, Broadcast, On-Demand, Guide Data, DOCSIS Internet, VoIP
- IPTV Head-Ends: Internet, Switched-Digital Video, On-Demand
- CDNs: Content Distribution/Delivery Networks with Streaming
- Viral Video and Social Networking Video/Audio Streaming
- Digital Cinema: HD Digital Projectors, 3D Digital Projectors
- Closed Circuit Security Systems: Multi-Camera NTSC/HD

© Sam Siewert
Digital VoD System End-to-End

Pitcher Catcher Video Vault

VoD Servers

DSL or FTTH

IPTV

Billing System

Edge QAMs

HFC Cable Network

STBs

gigE / 10G IP Transport Distribution Network

Digital VoD System End-to-End

© Sam Siewert
National On-Demand System with DRM (Digital Rights Management)
OTA 8VSB – HDTV

- **Local Coverage** for OTA HDTV
- Typically 1080p MPEG Carried on 8VSB
- Good Option to Capture Content for Class (Fair Use)
Digital Media Focus

Scalable Post Production Pipelines
- Multi-core Threading with POSIX Threads (CPU scaling)
- I/O Scheduling and Tuning (Disk bottlenecks and Capacity Scale)
  - RAID10, 50, 60, Beyond
  - Deadline Driven
  - NVM Architectures for Cache (PCIe Flash, NVM Express, SSD)

Real-time HD Frame Transformations
- Color Transformations, Edge Enhancement
- Integrated Graphics & Video (Interactive TV)
- Green Screen Replacement, Video Morphing
- Segmentation, Recognition, Tagging
- Post-Capture Focusing (Demonstrated at CES)
From Linux to Digital Media

Inspired by Linus Torvalds and Minix Pedagogical Unix
- Linus has now written 2% or less of Linux (But started it all!)
- Highly leveraged GNU open source tools (Richard Stallman)
- Open source Unix (hobby, full source OS), 1991
- Interest in interactive applications arose in mid 1990s
- Linux and Solaris have Dominated Digital Media/Web Services

Basis for AOS – Android Operating System

Systems Software for Many Head Ends
What’s Controversial, What Isn’t

Linux Hard Real-Time remains to Be Seen…
- HRT requires deterministic response from services (SW or HW)
- HRT SW services are tricky on modern microprocessors
- HRT Linux SW Services Risky
  - Many kernel features are not deterministic
  - Kernel is still not fully pre-emptable

Linux Soft Real-Time and Interactive is Well Proven
- Android Clients, Scalable Linux Head-Ends
- Continues tradition of Soft RT-Unix (e.g. LynxOS, Solaris)
- Very Few systems really are HRT
- HRT systems have few HRT and many BE and Soft services
What We Will Cover

- Linux Multi-Core Scheduling and Digital Media Processing, including GPU Vector Processing (SSE, CUDA, Many-Core)
- Digital Video and Audio Encoding and Decoding – MPEG2/4
- Digital Media Server File systems and storage
- Digital Media Transport
  - Broadband (modulated): OTA NTSC (Historical), ATSC, Digital Cable QAM
  - Baseband (Networked): IPTV, Viral Video
- Digital Cinema
- Interactive Systems with HTML5 and/or Flash
What We’ll Do

- Learn Linux Skills for Digital Media and Interactive Systems
- Learn Concepts and Theory
- Leverage Digital Video Open Source
  - Tools for Encode/Decode/Transform: ffmpeg, VLC, GIMP, OpenCV
  - Analysis Tools: E.g. TSReader, GIMP

Complete Linux-based Digital Video Labs
- Intro to NPTL and POSIX mechanisms in Linux
- Intro to MPEG Transport and Program Streams
- Digital video encode/decode

Complete an Extended Lab (Project)
- Digital Video (RT streaming and stream analysis)
- Trick-Play (Interactive)
- HTML5 and Flash Applications (Interactive)
Why?

Digital Media and Interactive - rapidly growing industry
- Post Production, Animation, Broadcast
- Interactive Systems (Games, Augmented Reality)
- On-Demand Media (Web, IPTV, Cable VoD)

Fundamentals of Video/Audio Encode and Decode
How to Deliver (Transport) Digital Media
How to Scale Systems to 100,000’s of Subscribers
You Too Could Work at DreamWorks, ILM, Microsoft
Local Industry: GCI, ACS, Cable-Labs, TWC, Liberty Media, Comcast, …
More Administrivia

Text Book – Digital Media Primer by Yue-Ling Wong
- Readings noted on Syllabus
- Will Provide DV standards to read like 13818-1, 13818-2
- We will read papers (industry and academic), provided on BB and website
Linux Demo – Real-Time Digital Video Capture and Transformation

Introduction Session
Demonstration of Real-Time Video Transformation

- Uses OpenCV
- Captures Digital Video
- Applies Sobel or Canny Transform
Papers with OpenCV Background

