Using Python in Software for the Medical Industry

Vertebral Fracture Analysis case study

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About the Speaker

- Software engineer by profession
  - Currently at Google (cloud products)
- Course instructor: teaching Python since 1998
  - Private Corporate Training & Public Courses
- Community volunteer
  - User groups: BayPIGgies and SF Python Meetup
  - Other: Tutor mailing list; Python conferences
- Author/co-author (books, articles, blog, etc.)
  - *Core Python Programming* ([2009,]2007, 2001)
  - *Python Fundamentals* LiveLessons DVD (2009)
  - *Python Web Development with Django* (2009)

I Teach
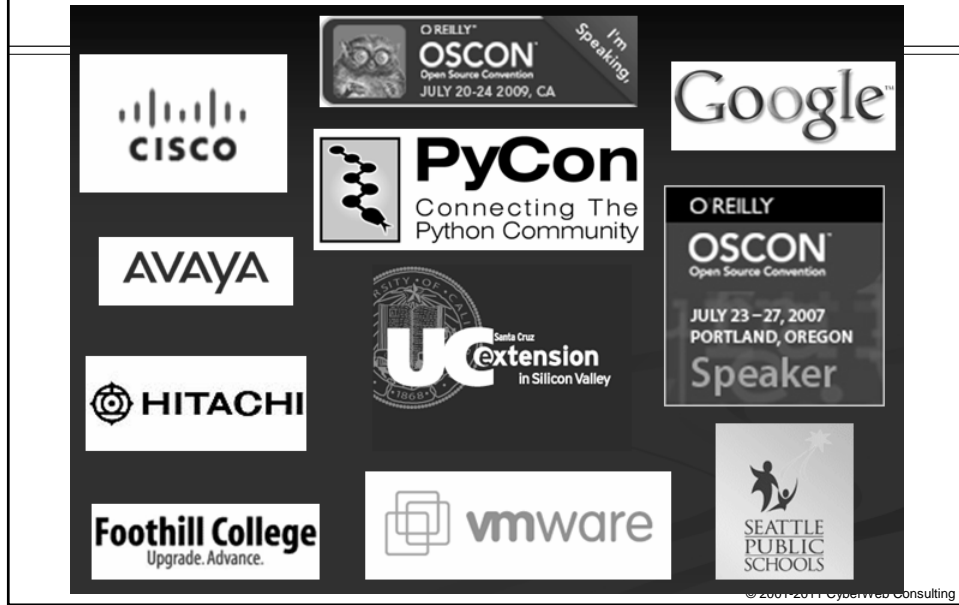
I Write
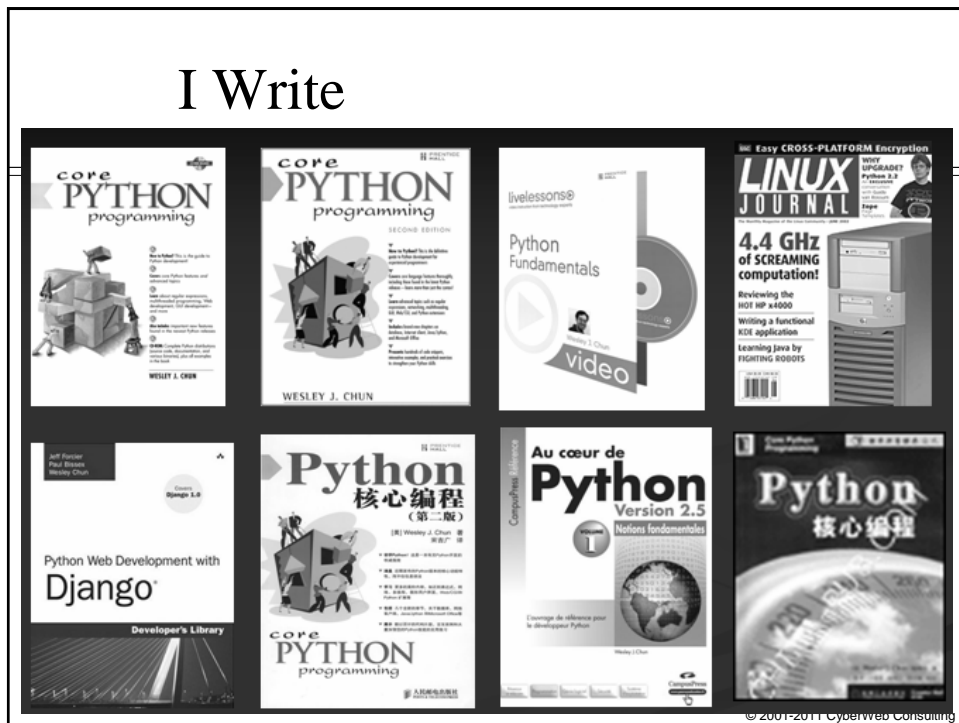
I Code

About this Talk

- Yes, this talk still has some Python in it! ☺
  – Mostly an architectural talk

- This work took place during my tenure at Synarc from 2001-2004
  – Synarc founded in 1998 by merging 4 leading university-based + 2 commercial service providers (CROs)

- Internet and networking senior software engineer transplanted into medical field during dot-bomb era
  – Experience using Python to develop medical apps
  – Gained much medical knowledge and industry insight
  – Still like a fish-out-of-water experience

Synarc Company Services

- Applications for the following areas in medicine:
  - Oncology
  - Neurodegenerative Disease
  - Osteoporosis
  - Molecular Markers
  - Arthritis and Orthopaedics

- Services (clinical trials: multiple phases)
  - Preliminary
  - Image Procurement and Data Entry
  - Reading Analysis and Patient Assessment
  - Study Completion

Image Reading System Products

- Radiology image media accepted from sponsors
  - Radiographs (X-Rays)
  - Computer Tomography (CT) "cat scan"
  - Magnetic Resonance Imaging (MRI)

- Application Software
  - Vertebral fracture analysis
  - Knee Joint Space Width
  - Rheumatoid Arthritis

- Used by radiologists and trained technicians
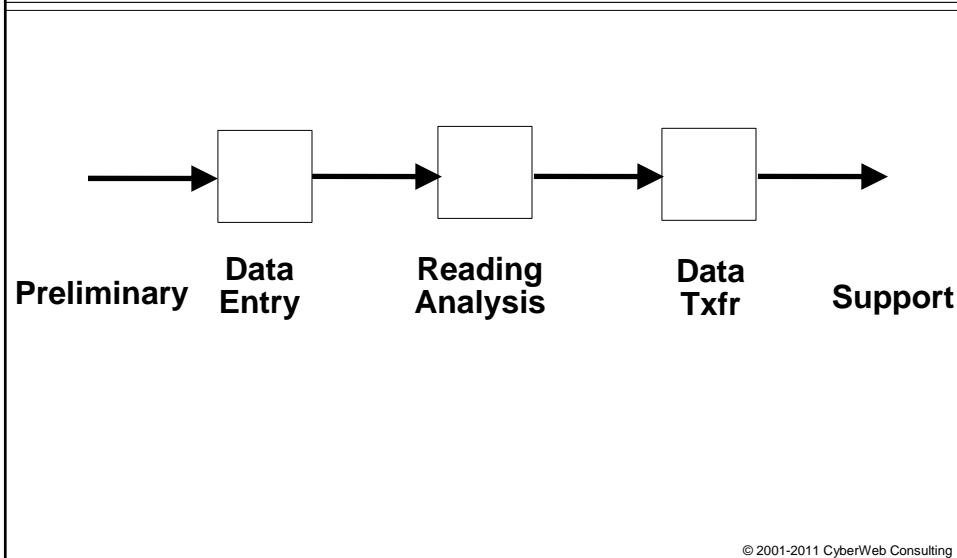
Synarc Application Software

Rheumatoid Arthritis

Knee Joint Space Width

Vertebral Fractures

Process and Data Flow

| Preliminary | Data Entry | Reading Analysis | Data Txfr | Support |

Motivation/Goals

- Help bring new medicines to market faster
  - But ensure safety and follow FDA guidelines
  - Must publish standard operating procedures
  - (we get audited almost once a month)
- Enable more productivity
  - Empowers doctors and trained technicians
  - Provide suitable substitute for film and film labor
  - Strong attempts to reduce human error
- End users all internal (doctors/technicians)
- Turnaround time critical
  - Contracts were signed years ago
  - Now receiving radiology data (X-rays)

Focus on Vertebral Fractures

- Assess/diagnosing vertebral fractures

- What is a fracture?
  - Any damage to any bone structure
  - Usually some sort of breakage
  - Can also be loss of structure, i.e., see below

- What is a vertebra? A bone of your spine
  - 3 kinds: cervical (7), thoracic (12), lumbar (5)
  - In total, they make up the spinal or vertebral column

- Main cause of vertebral fractures is *osteoporosis*

What Are Vertebral Fractures?

- 3 basic types of vertebral fractures
  - Bioconcave (central vertebral deformity)
  - Wedge (mostly anterior/posterior)
  - Crush (all of the above)

- Symptoms
  - Initial severe pain
  - Gradually reduces
  - Wears on (intervertebral) disks
  - Can cause bone growth to form
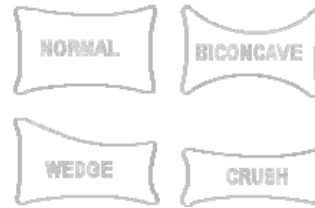
Causes of Vertebral Fractures

- Most due to postmenopausal osteoporosis

- What is osteoporosis (porous bone)?
  - **def**: A systematic skeletal disease characterized by low bone mass and microarchitectural or structural deterioration of bone tissue, leading to bone fragility and increased susceptibility to fractures
  - 80% of those affected are female
  - 1:2 women and 1:8 men over age 50
  - 1.5 million osteoporotic fractures annually
    - Almost half are vertebral fractures
  - No "symptoms" of osteoporosis – nothing happens until fracture
  - No known cure, but many believe highly preventable

Vertebral Fractures: What Happens

Normal Posture   **Compression**   **Advanced Osteoporosis**
Normal Spinal Segment   **Fracture**   **"Dowager's Hump"**

Vertebral Fracture Analysis Software

- **Software customized for each study**
  - Keep application stable; customize stored procedures

- **Veterbral Fracture system – graphical software app**
  - Augments manual assessment via eye and paper
  - Simplifies measurement by radiographic morphometry
  - Expedites analysis of clinical testing of treatments
  - Geared towards vertebral fractures
  - Primary Input: X-Ray (digital image)

- **Analysis Modes (4 separate tools):**
  - Identification: label vertebrae
  - Assessment: SQ, BSQ, QM
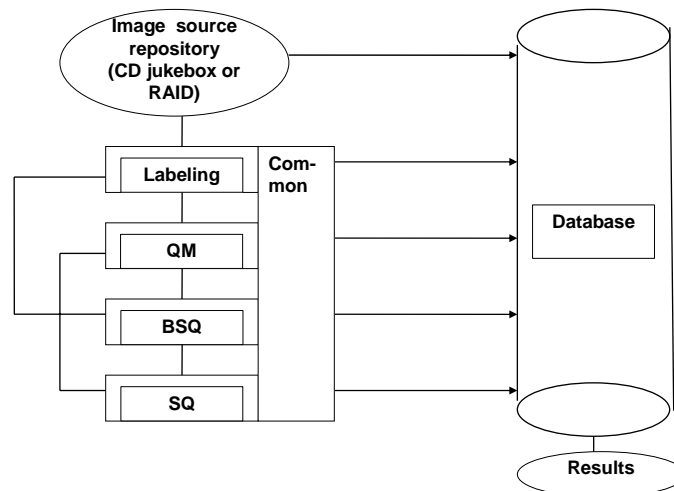
Reading System

- **Common**
  - Used by all reading system applications
- **Labeling**
  - Vertebral identification
- **Quantitative Morphometry**
  - Measurement via vertebral shape and ratios
- **Semi-Quantitative**
  - Assign grading to fracture severity
- **Binary Semi-Quantitative**
  - Identifies fractures and new or worsened conditions

System Components

Common Software Components

- **Database Interface**
  - Low-level common interface to the DB

- **Data Manager**
  - Manages dataflow b/w applications and DB

- **Graphics Libraries**
  - XIL – high resolution graphics rendering
    - Should port to OpenXIL or better yet, OpenGL
  - Tk – high-level graphical user interface (GUI)
    - Don't need complex widgets; just mouse-clicks!
  - Tkinter & Pmw – Python interface to Tk
    - Rapid development is a good thing

Labeling

- **Process of identifying vertebra**

- **Three (3) major components:**
  - LabelTool.sh (launches the main application)
  - LabelApplication.py (main application tool)
  - LabelTool.py (label tool for each radiograph)

- **Not considered assessment**
  - No electronic signature required
  - Can be performed by trained technician

Label Application Architecture

```
LabelTool (launcher Unix shell script)

    LabelApplication (main Label tool application)         Database
                                                           Interface
        LabelTool    LabelTool    LabelTool    LabelTool
                                                           VFData
        (one per X-                                        Manager
        ray film
        within
        application)                                       Tk/XIL
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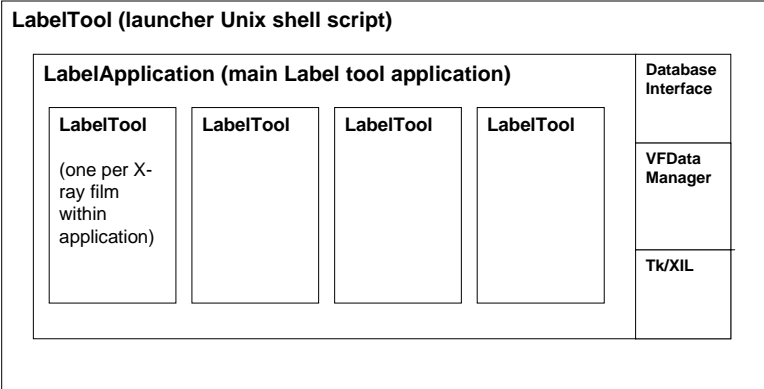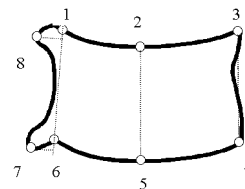
Quantitative Morphometry

■ Measuring the shape of each vertebra

■ Calculating the intrabone ratios
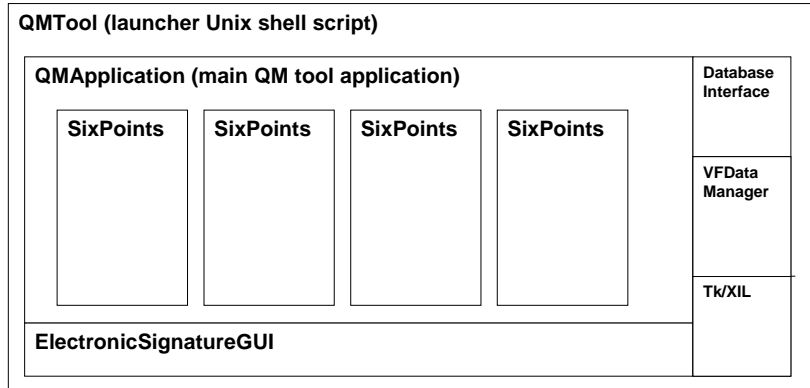 – Anterior / Medial / Posterior heights

■ Three (3) major components:
  – QMTool.sh (launches the main application)
  – QMApplication.py (main application tool)
  – SixPoints.py (QM tool for each radiograph)

■ Considered assessment
  – Electronic signature required
  – Can be performed by trained technician

QM Architecture

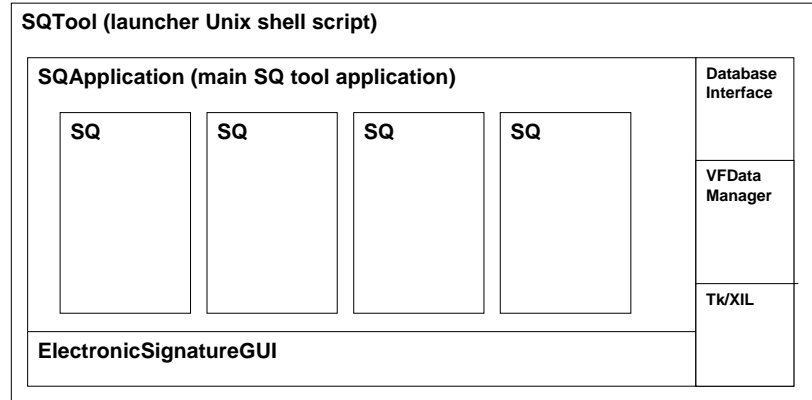| QMTool (launcher Unix shell script)				
QMApplication (main QM tool application)				**Database Interface**
SixPoints	SixPoints	SixPoints	SixPoints	**VFData Manager**
				Tk/XIL
ElectronicSignatureGUI				

Semi-Quantitative Scoring

- Grading of vertebral fractures
  - 0, 0.5, 1, 2, 3, N/A (cannot be determined/evaluated)
  - 0 = no/normal, 1 = mild, 2 = moderate, 3 = severe

- Three (3) major components:
  - SQTool.sh (launches the main application)
  - SQApplication.py (main application tool)
  - SQ.py (SQ tool for each radiograph)

- Considered assessment
  - Electronic signature required
  - Must be performed by radiologist

Semi-Quantitative Architecture

SQTool (launcher Unix shell script)

SQApplication (main SQ tool application)

| SQ | SQ | SQ | SQ |

ElectronicSignatureGUI

Database Interface

VFData Manager

Tk/XIL

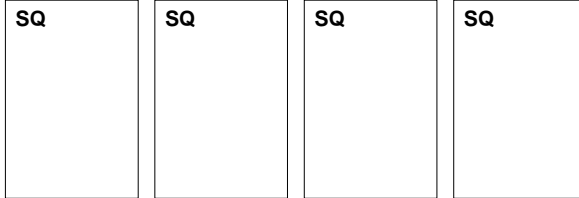
Binary Semi-Quantitative Scoring

- Identifying vertebral fractures and changes
  - 0, P, N/A (baseline); P = prevalent frx (preexisting)
  - 0, I, N/A (follow-up); I = incident frx (worsening)

- Three (3) major components:
  - BSQTool.sh (launches the main application)
  - BSQApplication.py (main application tool)
  - SQ.py (SQ tool for each radiograph)
  - Software nearly identitcal to code for SQ

- Considered assessment
  - Electronic signature required
  - Must be performed by radiologist

BSQ Architecture

BSQTool (launcher Unix shell script)

BSQApplication (main SQ tool application)

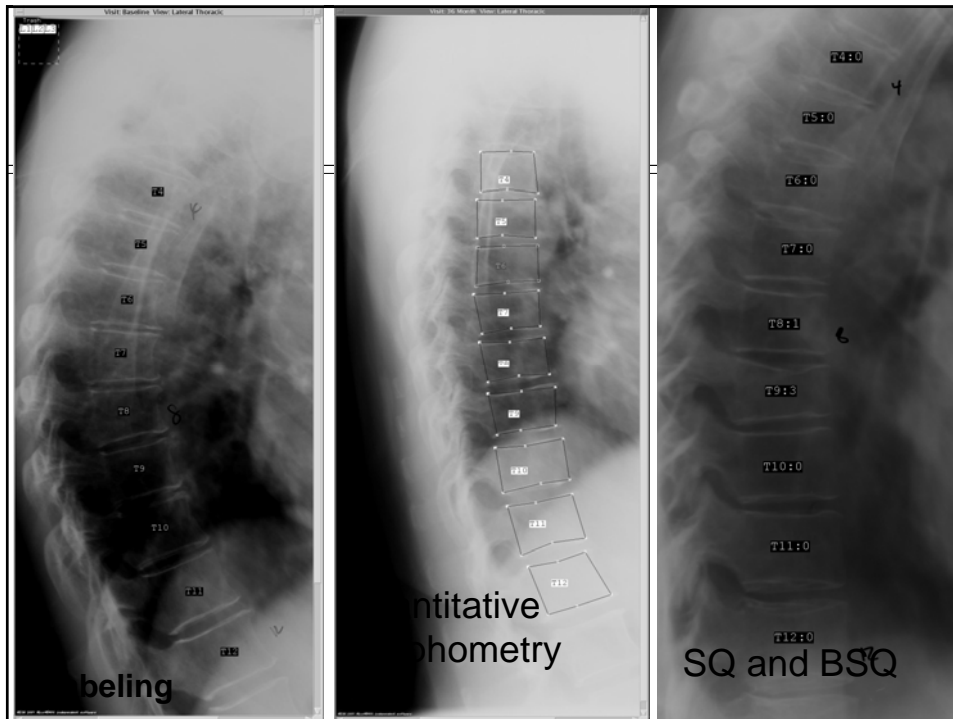| **SQ**	**SQ**	**SQ**	**SQ**

Database Interface

VFData Manager

Tk/XIL

ElectronicSignatureGUI

ntitative
ohometry

SQ and BSQ

beling

Data Flow

Radiographs from sponsor
Film

Graphic files from digitized radiographs
Lumisys, DICOM

Images loaded from CD jukebox or RAID

Labeling of radiograph image files

QM, BSQ, and/or SQ of labeled images

Data transfer back to sponsor
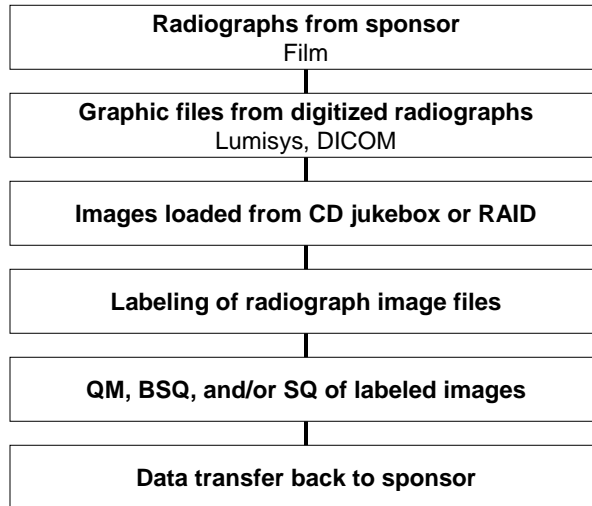
Software

- **Python (primary development language)**
  - Tk(inter), Pmw, and Sybase modules

- **Other open source tools**
  - Tcl, Tk, BLT; Perl, Apache, Samba, various GNU

- **Some proprietary tools:**
  - MS VB and Access
  - Sybase Transact SQL RDBMS
  - Sun Solaris and XIL high-res imaging library

Other System Components

- Hardware
  - Sun Microsystems Ultra 10
  - Single color visual monitor
  - Double high-resolution monochrome monitors

- Operating System
  - Sun Microsystems Solaris 8 (SunOS 2.8)

- Data Entry System
  - Assistants input incoming images, patient data
  - Data Entry screens in VB -> Access -> SYBS

Past, Current, Future

- Why Python?
  - Python chosen for rapid development time
  - Original engineer had 4 months to do it all
  - I rearchitected major pieces, added new features,…

- 80% of all Synarc applications in Python
  - Vertebral Fracture, Joint Space Width
  - Various imaging tools, digitizer, etc.
  - Rheumatoid Arthritis (older app in Tcl/Tk)

- Today: state is not as good
  - A Java-centric came in a forced a rewrite of all tools
  - That was 2004. In 2011, those tools just rolling out
  - Yet original Python tools have been yielding $$

Online Resources

- Synarc
  - http://www.synarc.com
- University of California, San Francisco
  - Department of Radiology / Osteoporosis-Arthritis Research Group
  - http://www.oarg.ucsf.edu
- National Osteoporosis Foundation
  - http://www.nof.org
- The Type and Effect of Vertebral Fractures
  - http://www.osteoporosis-centre.org/oc_vfrac.htm
- Osteoporosis Centre
  - http://www.osteoporosis-centre.org
- Papers in related areas (software & medical)
  - http://archive.nlm.nih.gov/pubs/biblio/biblio.php

Conclusion

- **Python Advantage**
  - Not locked to any particular vendor
  - Variety of development tools – your choice!
  - Ability to deliver mission-critical products
  - Extremely rapid development time
    - High importance given industry timelines

- **And now for something completely different!**
  - Medical software for doctors
  - Perform patient assessments on X-Rays

Recent+Upcoming Events

- Oct 18-20: Intro+Inter. Python course, San Francisco
  - http://cyberwebconsulting.com
- Jul 25-29 O'Reilly Open Source (OSCON), Portland
  - http://oscon.com
- Jul 11-13 ACM CSTA CS&IT Conference, NYC
  - http://www.csitsymposium.org
- Jun 20-25 EuroPython, Florence
  - http://europython.eu
- May 8-10: Google I/O, San Francisco
  - http://google.com/io