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
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

Vertebral Fractures

Knee Joint Space Width

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

Vertebral Fracture Analysis Software

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

- Vertebral 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

- Image source repository (CD jukebox or RAID)
- Labeling
- QM
- BSQ
- SQ
- Database
- Results
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
VFData Manager
Tk/XIL

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)
  - QMAplication.py (main application tool)
  - SixPoints.py (QM tool for each radiograph)
- Considered assessment
  - Electronic signature required
  - Can be performed by trained technician
QM Architecture

QM Tool (launcher Unix shell script)

QMAplication (main QM tool application)

SixPoints
SixPoints
SixPoints
SixPoints

Database Interface

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
## 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 identical to code for SQ

- Considered assessment
  - Electronic signature required
  - Must be performed by radiologist
**BSQ Architecture**

<table>
<thead>
<tr>
<th>BSQTool (launcher Unix shell script)</th>
<th>BSQApplication (main SQ tool application)</th>
<th>Database Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ</td>
<td>SQ</td>
<td>VFDData Manager</td>
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<tr>
<td>SQ</td>
<td>SQ</td>
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<td>ElectronicSignatureGUI</td>
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</tbody>
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**BSQ and BSQ**

**Quantitative Morphometry**

**Labeling**
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](http://www.synarc.com)
- University of California, San Francisco
  - Department of Radiology / Osteoporosis-Arthritis Research Group
  - [http://www.oarg.ucsf.edu](http://www.oarg.ucsf.edu)
- National Osteoporosis Foundation
  - [http://www.nof.org](http://www.nof.org)
- The Type and Effect of Vertebral Fractures
  - [http://www.osteoporosis-centre.org/oc_vfrac.htm](http://www.osteoporosis-centre.org/oc_vfrac.htm)
- Osteoporosis Centre
  - [http://www.osteoporosis-centre.org](http://www.osteoporosis-centre.org)
- Papers in related areas (software & medical)

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