SNIA Long Term Retention for Medical AI Applications

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Introduction

  - SIRF defines a storage container for long term retention and preservation
  - Results from a long journey of SNIA Long Term Retention technical working group

- Medical analytics such as in the BigMedilytics project requires a lot of scarce data that should be retained for the long term

- In this presentation, I’ll discuss the use of SIRF for medical artificial intelligence (AI) via Medical AI Bank
Outline

- Digital preservation challenges
- The SIRF standard
- Breast cancer pilot in BigMedilytics
- SIRF for medical AI
- Summary
Need for Digital Preservation of Big Data

- Regulatory compliance and legal issues
  - Sarbanes-Oxley, HIPAA, FRCP, intellectual property litigation
- Emerging web services and applications
  - Email, photo sharing, web site archives, social networks, blogs
- Many other fixed-content repositories
  - Scientific data, intelligence, libraries, movies, music
- Domains that have Big Data require preservation

Scientific and Cultural

Satellite data is kept for ever

We would like to keep digital art for ever

M&E

Film Masters, Out takes. Related artifacts (e.g., games). 100 Years or more

Healthcare

X-rays are often stored for periods of 75 years

Records of minors are needed until 20 to 43 years of age

Scientific and Cultural

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Goals and Threats of Digital Preservation

Digital assets stored now should remain
- Accessible
- Undamaged
- Usable

For as long as desired – beyond the lifetime of
- Any particular storage system
- Any particular storage technology

Threats
- Media/hardware obsolescence
- Software/format obsolescence
- Lost context/metadata

Faults
- Economic faults
- Organizational faults
- Human error
- Attack

Requires both physical preservation and logical preservation and at an affordable cost
What is Long Term?

The 100-Year Archive Survey Results 2007 and 2017
Solutions

- Solutions are now becoming available
  - Standards – OAIS, VERS, MoReq, …
  - Storage formats - SIRF, OpenAXF, PREMIS, BagIt,…
  - Software – Fedora, LOCKSS, DSpace, Arkivum, iRods, Rosetta, …
  - Cloud Services – Preservica, Duracloud, Chronopolis, Dternity, Glacier, …

- But, their usage is still limited
  - Primarily used in government agencies, libraries, and highly regulated industries

- Why
  - Lack of education or understanding?
  - Lack of need, will, funding, etc.? Lack of penalties?
  - Short term focus?
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SIRF: Self-contained Information Retention Format

An Analogy

- Standard physical archival box
  - Archivists gather together a group of related items and place them in a physical box container
  - The box is labeled with information about its content e.g., name and reference number, date, contents description, destroy date

- SIRF is the digital equivalent
  - Logical container for a set of (digital) preservation objects and a catalog
  - The SIRF catalog contains metadata related to the entire contents of the container as well as to the individual objects
  - SIRF standardizes the information in the catalog

Photo courtesy Oregon State Archives
SIRF Properties

- SIRF is a logical data format of a **storage container** appropriate for long term storage of digital information
  - A storage container may comprise a logical or physical storage area considered as a unit.
    - Examples: a file system, a tape, a block device, a stream device, an object store, a data bucket in a cloud storage

- Required Properties
  - **Self-describing** – can be interpreted by different systems
  - **Self-contained** – all data needed for the interpretation is in the container
  - **Extensible** – so it can meet future needs
SIRF Components

A SIRF container includes:

- A **magic object**: identifies SIRF container and its version
- **Preservation objects** (PO) which are immutable
- A **catalog** that is
  - Updatable
  - Contains metadata to make container and preservation objects portable into the future without external functions

SIRF is inspired by the Open Archival Information System (OAIS) - ISO 14721:2003
The SIRF catalog includes metadata organized in a hierarchy of categories, elements and attributes. The categories are:

- Container information:
  - Specification
  - Container ID
  - State
  - Provenance
  - Audit Log

- For each Preservation Object:
  - Object IDs
  - Related Objects
  - Dates
  - Packaging Format
  - Fixity
  - Retention
  - Audit Log
  - Extension
PO Information – IDs Category

Elements:

- **PO name (objectName)** – non unique identifier e.g. file name

- **PO version ID (objectVersionIdentifier)** – unique identifier that identifies the specific version of the PO

- **PO logical ID (objectLogicalIdentifier)** - a unique identifier that identifies the various versions that originate from the same ancestor

- **PO parent ID (objectParentIdentifier)** - a unique identifier that identifies the parent PO from which this PO version was created. Parent PO shares the same logical ID as the current PO, but has different version ID.
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BigMedilytics is an EU project on medical Big Data
• Aims to transform Europe’s Healthcare by using state-of-the-art Big Data technologies to:
  • reduce costs
  • improve patient outcomes
  • deliver better access to healthcare facilities
• A Private Public Partnership project (PPP)
• Includes 12 pilots in 3 themes:

[Diagram showing themes: Population Health & Chronic Disease Management, Oncology, Industrialization of Healthcare Services, with specific conditions like Comorbidities, Kidney, Diabetes, COPD/Asthma, Heart Failure, Prostate, Lung, Breast, Stroke, Sepsis, Asset, Radiology]
**Breast Cancer Pilot**

**Goals:** Improve treatment response for breast cancer by using AI to analyze MG, US, and MRI images along with structured clinical data. Reduce costs by tailoring treatment for the individual patient.

- **IBM**
  - Pilot lead
  - Image analytics
  - Clinical data analytics
  - Deep learning

- **Institute Curie**
  - Patient data (images and clinical)
  - Clinical knowledge
  - Data hosting

- **VTT**
  - Image analysis
  - Interpretable features
Breast Cancer Pilot

• Neoadjuvant Chemotherapy Treatment (NACT) is a treatment option in breast cancer
  • Decision today is made based on: tumor size (T3, T4), patient preference for breast conservation, hormonal receptors, HER2
  • Less than half of treated patients achieve pathological complete response with no evidence of cancer cells
  • Failed treatment delays a more effective treatment

• Radiomics can improve NACT response prediction
  • Extract large amount of quantitative features from multi modal medical images
  • Apply advanced deep learning and computer vision algorithms for precision medicine applications
Curie Heterogenous Data Collection

Clinical data
Side (Left, Right), grade, hormonal receptors (estrogen, progesterone, HER2, Ki-67...)

Treatment
Chemotherapy: Date, protocol, drugs, chemo lines...
Surgery: Date, breast and/or axillary surgery, lymph nodes invaded/removed...
Other: Radiotherapy, hormonotherapy, immunotherapy

Response to treatment
Several scoring methods: Chevalier, Sataloff, RCB, ypTN

Patient data
Age at diagnosis, sex, weight, height, other tumors...

Imaging
MRI, MG, US...

Other
Genetic Transcriptomic

Cancer progression
Possible relapses/metastasis

Other
Age at diagnosis, sex, weight, height, other tumors...
Pilot Architecture

- Model-to-Data paradigm
- Suitable for on-prem or on-cloud
- All data and results on shared storage
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• For medical AI we need big data and some of it annotated

• But getting the medical data is difficult
  • The data is scarce and distributed
  • Needs preprocessing
    • e.g. no standardized protocol for MRI scan acquisition
  • Adding annotations is expensive
  • Adhere to privacy regulations e.g. GDPR

• The need for Medical AI Bank
  • Analytics-ready data that is preserved for future research
  • Based on medical standards (DICOM, HL7 FHIR, ICD-10, UMLS,…)
  • Can get individual’s data donations after his lifetime
  • Includes storage containers with SIRF serialization
Goals of SIRF Serialization for Cloud/FS

- SIRF serialization for Cloud/FS specifies how a SNIA Cloud Data Management Interface (CDMI) cloud container or Linear Tape File System (LTFS) tape also becomes SIRF-compliant.

- A SIRF-compliant cloud or file system containers enable a future storage client to “understand” containers created by today’s storage client:
  - The properties of the future client is unknown to us today
  - “understand” means identify the preservation objects in the container, the packaging format of each object, its fixities values, etc. (as defined in the SIRF catalog)

- OpenSirf is an open source implementation of SIRF serialization for the cloud.
SIRF Serialization for Cloud

- SIRF magic object is mapped to the CDMI container metadata
- SIRF catalog is an object in the CDMI container formatted in JSON
- SIRF Simple/Composite PO is mapped to CDMI data object/set of data objects

```
sirfCatalog
{
  "encounterJan2001":{
    "IDs": ["..."]
  }
}
```

```
chestImage
{
  "IDs": ["..."],
  "Fixity": ["..."]
}
```

```
Simple PO
```

```
Encounter Jan2001
```

```
Composite PO
```

SIRF magic object:
- specification=1111
- SIRF level = 1
- Catalog object=sirfCatalog
SIRF Serialization for LTFS Tape

- SIRF magic object is mapped to extended attributes of the "LTFS index” root directory
- SIRF catalog resides in the index partition and formatted in XML
- SIRF Simple/Composite PO is mapped to a LTFS file/set of files
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Summary
Need to retain not only information of interest but ALL other information to make it fully usable in the future

- Put it all in the SIRF “digital box”, preserve that as a unit
- SIRF includes metadata about the storage container, to help “understand” the contents of the container in the future

Medical AI Bank is a vision that requires digital preservation

- Utilize SIRF for collecting all of the information that will be needed to transition to new technologies in the future
- SIRF can be serialized for the future technologies as they come
For further information

- SIRF specification
  https://www.iso.org/standard/76648.html
  http://www.snia.org/tech_activities/standards/curr_standards/sirf

- More information on SIRF & SNIA LTR activities
  http://www.snia.org/ltr

- OpenSIRF is available at:
  http://github.com/opensirf

- BigMedilytics EU project
  https://www.bigmedilytics.eu/
Thank You

Muchas Gracias

תודה רבה

Merci Beaucoup

Vielen Dank