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https://github.com/cylab-tw

Design of HL7 FHIR Profiles for Pathology Reports Integrated with Pathology Images

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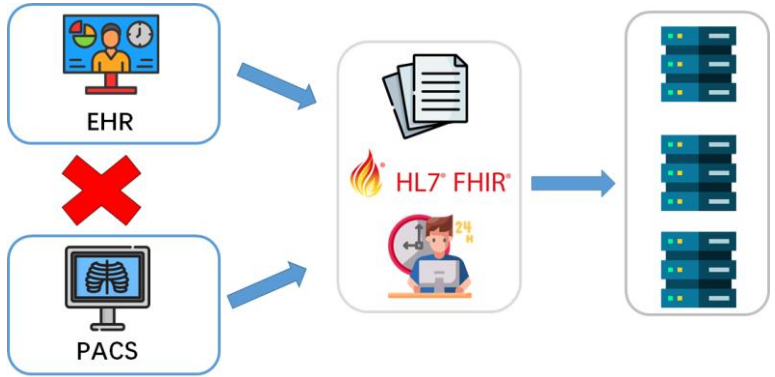
AIDH IMIA

Introduction

- The pathology report is often unstructured and heterogeneous across different systems.
- The lack of interoperability for data collection and analysis across multiple institutions.
- The HL7 FHIR is expected to solve this interoperability problem and improve the usability of health data.



The aim of this study

- Create and test an interoperability model for pathology reports with associated DICOM whole-slide images.
  - Adhere to the American Joint Committee on Cancer (AJCC) 8th checklist for diagnostic items.

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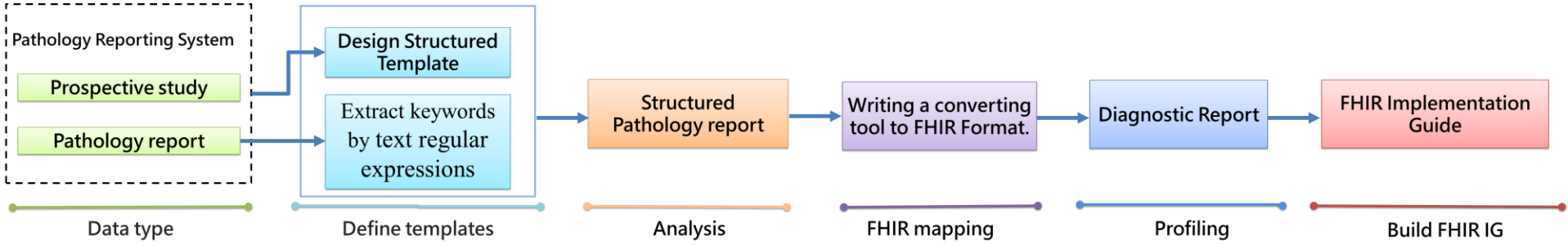

The pipeline for profiling FHIR IG

Methods

- Data source
  - 190 prospective admissions from Taipei Veterans General Hospital
  - Non-small cell lung cancer pathology report
- The structure of report
  - Pathological diagnosis
  - Gross finding
  - Microscopic finding

The format of the pathology report

PATHOLOGICAL DIAGNOSIS:
1. Lung, right lower lobe, segmentectomy
   --- Adenocarcinoma, acinar predominant, pT1aN0

GROSS FINDING:
The specimen received in formalin has 3 parts. Part (A) consists of a piece of lung, labeled RLL segment and measures 6.5 x 3.3 x 1.8 cm.

MICROSCOPIC FINDING:
1. Histologic type: adenocarcinoma, acinar predominant
2. Histologic pattern: acinar (90%), lepidic (10%)
3. Cell type: non-mucinous tumor cells
4. Total tumor size: 0.6 x 0.4 cm (microscopic measurement)
5. Size of invasive focus: 0.6 cm
6. Tumor grading (WHO 2021): grade 2 (moderately differentiated)
7. Angiolymphatic invasion: absent
8. Perineural invasion: absent
9. Spread Through Air Spaces (STAS): absent

Methods – Data collection

- Data source
  - 190 prospective admissions from Taipei Veterans General Hospital
  - Non-small cell lung cancer
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free text

free text and itemized forms

The format of the pathology report

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Methods – The design of FHIR profile

Pathological diagnosis

State the diagnostic results for tumor information

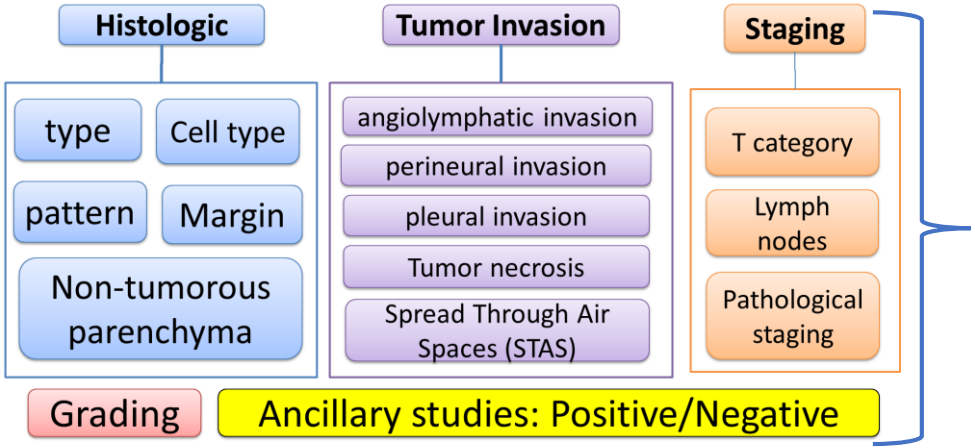
Gross finding

The specimen's status in the microscopy

Free-text stored in **FHIR Observations**

Microscopic findings

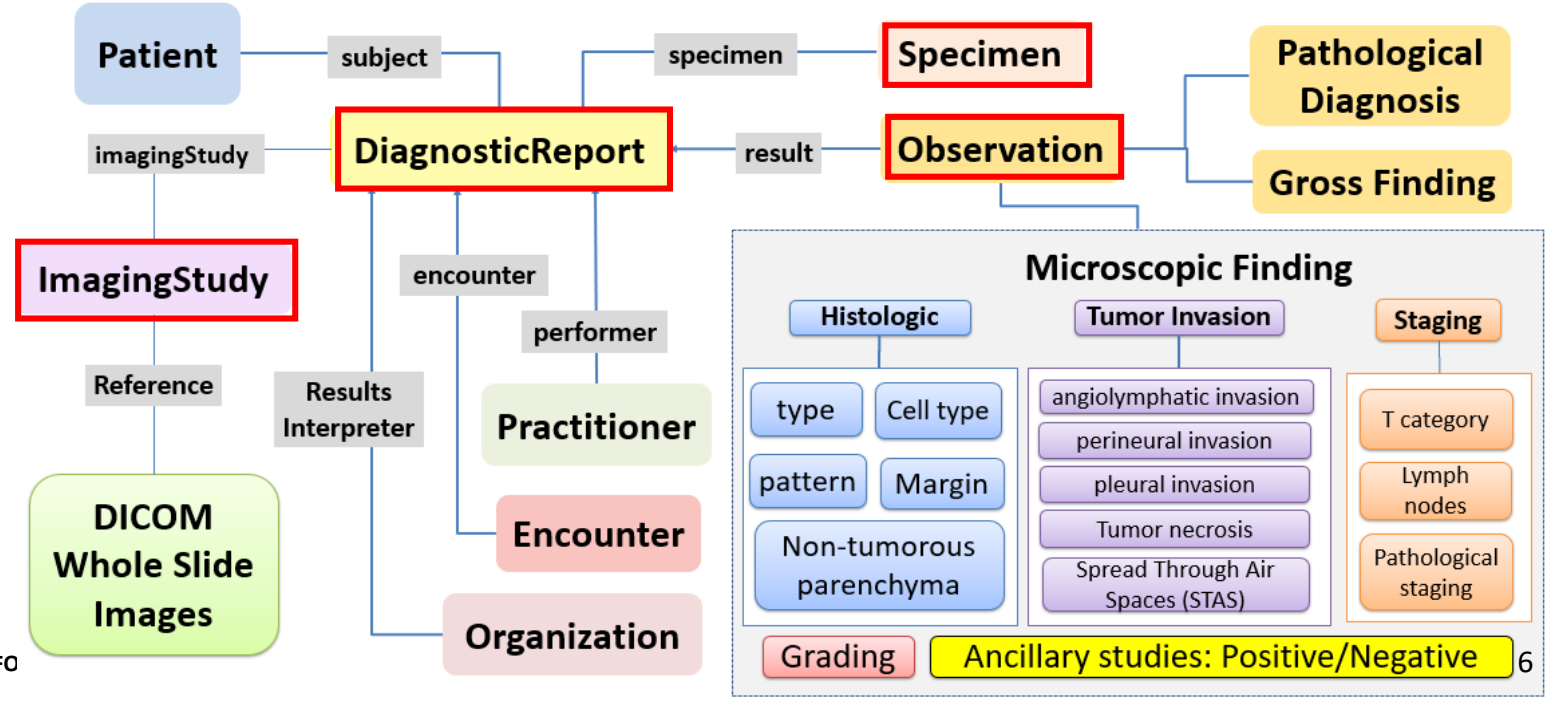
Describing the detailed information



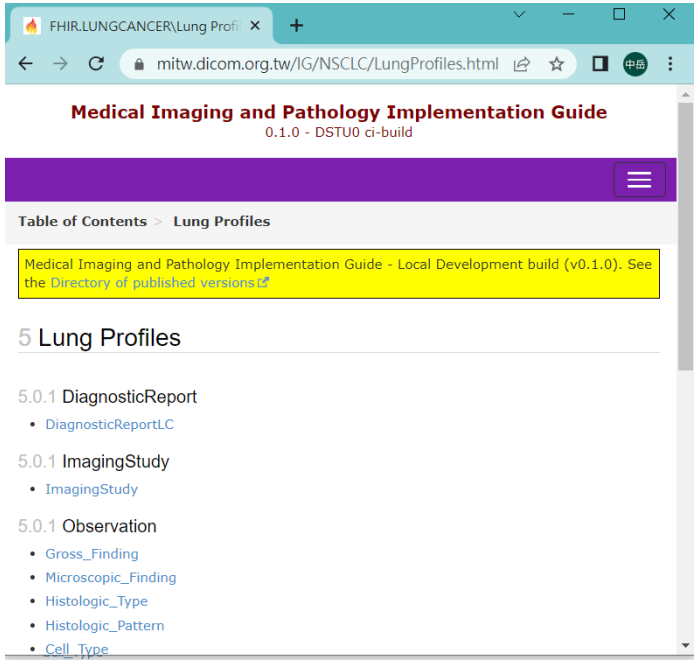
Using text regular expressions to extracting the **medical vocabularies** to convert to **FHIR Observations** encoded by AJCC 8th

The architecture of the FHIR profiles

25 profiles



Results – FHIR IG



https://mitw.dicom.org.tw/IG/NSCLC/

5.0.1 DiagnosticReport
- DiagnosticReportLC

5.0.1 ImagingStudy
- ImagingStudy

5.0.1 Observation
- Gross_Finding
- Microscopic_Finding
- Histologic_Type
- Histologic_Pattern
- Cell_Type
- Resection_Margin
- Nontumorous_Parenchyma
- Total_Tumor_Size
- Size_Of_Invasion_Focus
- Angiolymphatic_Invasion
- Perineural_Invasion
- Pleural_Invasion
- Spread_Through_Air_Spaces
- Tumor_Necrosis
- T_Category
- Lymph_Nodes
- Metastasis
- Pathological_Staging
- Tumor_Grading
- Treatment_Effect
- Ancillary_Studies
- DiagnosticReportLC
- ImagingStudy

5.0.1 Specimen
- SpecimenLC

Name	Flags	Card.	Type	Description & Constraints
DiagnosticReport		0..*	DiagnosticReport	診斷報告一由請求資訊、不可被中斷的一個或一系列結果（atomic results）、影像、解釋以及格式化報告所組成。
identifier	S	1..1	Identifier	報告的業務用識別碼
system	S	1..1	uri	機構識別碼（identifier）的命名空間（namespace）
value	S	1..1	string	檢查單號(Accession No.)
status	S	1..1	code	registered | partial | preliminary | final + **Binding:** DiagnosticReportStatus (required)
category	S	0..*	CodeableConcept	Service category **Required Pattern:** At least the following
coding		1..*	Coding	Code defined by a terminology system **Fixed Value:** (complex)
system		1..1	uri	Identity of the terminology system **Fixed Value:** http://loinc.org
code		1..1	code	Symbol in syntax defined by the system **Fixed Value:** LP7839-6
display		1..1	string	Representation defined by the system **Fixed Value:** Pathology
code	S	1..1	CodeableConcept	Name/Code for this diagnostic report **Required Pattern:** At least the following
coding		1..*	Coding	Code defined by a terminology system **Fixed Value:** (complex)
system		1..1	uri	Identity of the terminology system **Fixed Value:** http://loinc.org
code		1..1	code	Symbol in syntax defined by the system **Fixed Value:** 60568-3
display		1..1	string	Representation defined by the system **Fixed Value:** Pathology Synoptic report
subject	S	1..1	Reference(Patient)	報告的對象一通常但不總是病人
encounter	S	0..1	Reference(Encounter)	請求醫療資源時的健康照護事件
effective[x]	S	0..1	dateTime, Period	與臨床相關的時間／報告的時段
issued	S	0..1	instant	此版本完成的日期時間
performer	S	1..*	Reference(Practitioner)	對診斷服務負責者
resultsInterpreter	S	0..*	Reference(Practitioner |	主要結果的解釋者
specimen	S	1..*	Reference(Specimen)	此報告所依據的檢體
result	S	1..*	Reference(Observation LC Gross Finding | Observation LC Microscopic Finding | Observation LC Histologic type | Observation LC Histologic pattern | Observation LC Cell type | Observation LC Resection margin | Observation LC Non-tumorous parenchma | Observation LC Total tumor size | Observation LC Size of invasion focus | Observation LC Angiolymphatic invasion | Observation LC Perineural invasion | Observation LC Pleural invasion | Observation LC Spread Through Air Spaces (STAS) | Observation LC Tumor necrosis | Observation LC T category | Observation LC Lymph nodes | Observation LC Metastasis | Observation LC Pathological staging | Observation LC Tumor grading | Observation LC Ancillary studies)	診斷結果
imagingStudy	S	0..*	Reference(ImagingStudy)	參照至與診斷報告相關的成像之全部細節
media	S	0..*	BackboneElement	與此報告相關的關鍵影像
comment	S	0..1	string	關於影像的意見（例如：解釋）。
link	S	1..1	Reference(Media)	參照的影像來源
conclusion	S	0..1	string	診斷結果的臨床結論（解釋）
conclusionCode	S	0..*	CodeableConcept	診斷結果的臨床結論的代碼，此為SNOMED CT代碼，若機構已有購買相關授權，亦可使用。 **Binding:** SNOMEDCTClinicalFindings (example)
presentedForm		0..*	Attachment	已發佈的整個報告

20 Observation Profiles to represent the Microscopic findings

The Differential Table of the DiagnosticReport

Adopted ICD-10 PCS for Imaging Procedure

This code system `http://mitwfhir.dicom.org.tw/fhir/CodeSystem/ICD-10-procedurecode` defines the following codes:

Code	Display
B34JZZ3	Ultrasonography of Left Upper Extremity Arteries, Intravascular
B34JZZZ	Ultrasonography of Left Upper Extremity Arteries
B34KZZ3	Ultrasonography of Bilateral Upper Extremity Arteries, Intravascular
B34KZZZ	Ultrasonography of Bilateral Upper Extremity Arteries
B34RZZ3	Ultrasonography of Intracranial Arteries, Intravascular
B34RZZZ	Ultrasonography of Intracranial Arteries
B34SZZ3	Ultrasonography of Right Pulmonary Artery, Intravascular
B34SZZZ	Ultrasonography of Right Pulmonary Artery
B34TZZ3	Ultrasonography of Left Pulmonary Artery, Intravascular
B34TZZZ	Ultrasonography of Left Pulmonary Artery
B34VZZ3	Ultrasonography of Ophthalmic Arteries, Intravascular
B34VZZZ	Ultrasonography of Ophthalmic Arteries

Expansion Example: NSCLC Histologic pattern

Expansion based on NSCLC-Histologic-pattern v0.1.0 (CodeSystem)

Code	System	Display
lepidic	http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-Histologic-pattern	lepidic
acinar	http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-Histologic-pattern	acinar
papillary	http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-Histologic-pattern	papillary
micropapillary	http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-Histologic-pattern	micropapillary
solid	http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-Histologic-pattern	solid

Results – Terminologies for TNM Stage

Code	Display
TX	pTX
T0	pT0
Tis	pTis
T1	pT1
T1mi	pT1mi
T1a	pT1a
T1b	pT1b
T1c	pT1c
T2	pT2
T2a	pT2a
T2b	pT2b
T3	pT3
T4	pT4

T Stage

Code	Display
NX	pNX
N0	pN0
N1	pN1
N2	pN2
N3	pN3

N Stage

Code	Display
MX	pMX
M0	pM0
M1	pM1
M1a	pM1a
N1b	pM1b
N1c	pM1c

M Stage

Code	Display
0	0
IA1	Stage IA1
IA2	Stage IA2
IA3	Stage IA3
IB	Stage IB
IIA	Stage IIA
IIB	Stage IIB
IIIA	Stage IIIA
IIIB	Stage IIIB
IIIC	Stage IIIC
IVA	Stage IVA
IVB	Stage IVB

TNM Stage

Mapping Example

1. Histologic type: lymphoepithelial carcinoma
2. Tumor size: 4.5 x 2.2 x 2.1 cm
3. Tumor differentiation: poorly differentiated
4. Angiolymphatic invasion: absent
5. Perineural invasion: absent
6. Spread Through Air Spaces (STAS): absent
7. Tumor necrosis: present
8. Pleural invasion: invades beyond the elastic layer (PL1)
9. Bronchus cut end: free of tumor involvement
10. Non-tumorous parenchyma: congestion
11. T category:
    Tumor >4 cm but <= 5 cm in greatest dimension (pT2b)
12. Lymph nodes:
    - The paratracheal (1/10) and lower paratracheal (2/4) lymph nodes have metastatic carcinoma (N2).
    - Largest metastasis size: 0.8 cm
    - Extracapsular extension: absent
13. Pathological staging: pT2bN2 (AJCC 8th edition).


```
"category": {
  "coding": [
    {
      "system": "http://hl7.org/fhir/R4/codesystem-observation-category.html",
      "code": "laboratory",
      "display": "Laboratory"
    }
  ]
},
"code": {
  "coding": [
    {
      "system": "http://loinc.org",
      "code": "21899-0",
      "display": "Primary tumor.pathology Cancer"
    }
  ]
},
"subject": {
  "reference": "Patient/MitwPatient"
},
"valueCodeableConcept": {
  "coding": [
    {
      "system": "http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-pT",
      "code": "T2b",
      "display": "pT2b"
    }
  ]
}
```

Mapping Example


```
"category": {
  "coding": [
    {
      "system": "http://hl7.org/fhir/R4/codesystem-observation-category.html",
      "code": "laboratory",
      "display": "Laboratory"
    }
  ]
},
"code": {
  "coding": [
    {
      "system": "http://loinc.org",
      "code": "21900-6",
      "display": "Regional lymph nodes.pathology [Class] Cancer"
    }
  ]
},
"subject": {
  "reference": "Patient/MitwPatient"
},
"valueCodeableConcept": {
  "coding": [
    {
      "system": "http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-pN",
      "code": "N2",
      "display": "pN2"
    }
  ],
  "text": "- The paratracheal (1/10) and lower paratracheal (2/4)lymph nodes have metastatic carcinoma (N2).- Largest metastasis size 0.8 cm- Extracapsular extension absent"
}
```


12. Lymph nodes:
    - The paratracheal (1/10) and lower paratracheal (2/4) lymph nodes have metastatic carcinoma (N2).
    - Largest metastasis size: 0.8 cm
    - Extracapsular extension: absent

Mapping Example

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      "code": "laboratory",
      "display": "Laboratory"
    }
  ]
},
"code": {
  "coding": [
    {
      "system": "http://snomed.info/sct",
      "code": "397005006",
      "display": "World Health Organization tumor classification (observable entity)"
    }
  ]
},
"subject": {
  "reference": "Patient/MitwPatient"
},
"valueCodeableConcept": {
  "coding": [
    {
      "system": "http://mitwfhir.dicom.org.tw/fhir/CodeSystem/NSCLC-Grading",
      "code": "G1",
      "display": "Grade group 1"
    }
  ]
}
```

3. Tumor differentiation: poorly differentiated

Code	Display	Definition
G1	Grade group 1	Well differentiated
G2	Grade group 2	Moderately differentiated
G3	Grade group 3	Poorly differentiated
G4	Grade group 4	Undifferentiated
GX	Cannot be assessed	Cannot be assessed
GN	Not applicable	Not applicable.

Discussion

- It is critical in ensuring that the used medical vocabulary covers all the value sets required for the design of the value sets in the system analysis stage.
- Tumor, node, metastasis (TNM) staging varies for different types of cancers, and even within the same staging symbol, there may be slight differences in its meaning.
- Determining the hospital's coding book is critical, as this may affect whether subsequent value sets need to be customized.
- To improve the report's integration with its entire slide images, it is advisable to utilize the ImagingStudy resource to link the DICOM-encoded images.

Conclusions

- We have created cancer-related profiles in the form of an FHIR IG, containing FHIR resources relevant to the non-small cell lung cancer pathology report.
  - Converting the text-based pathology reports into structured forms.
  - Mapping the itemized vocabulary to the FHIR observation resources.
- The proposed FHIR IG will be tested in the Medical Informatics Taiwan (MI-TW) Connectathon.
  - 2-5 October 2023, Taipei, Taiwan.

Special Acknowledgments

- Main contributors
  - Tzu-Yun Ting (丁子芸)
  - Li-Chun Kuo (郭俐君)

They are preparing their master's degree defense now.

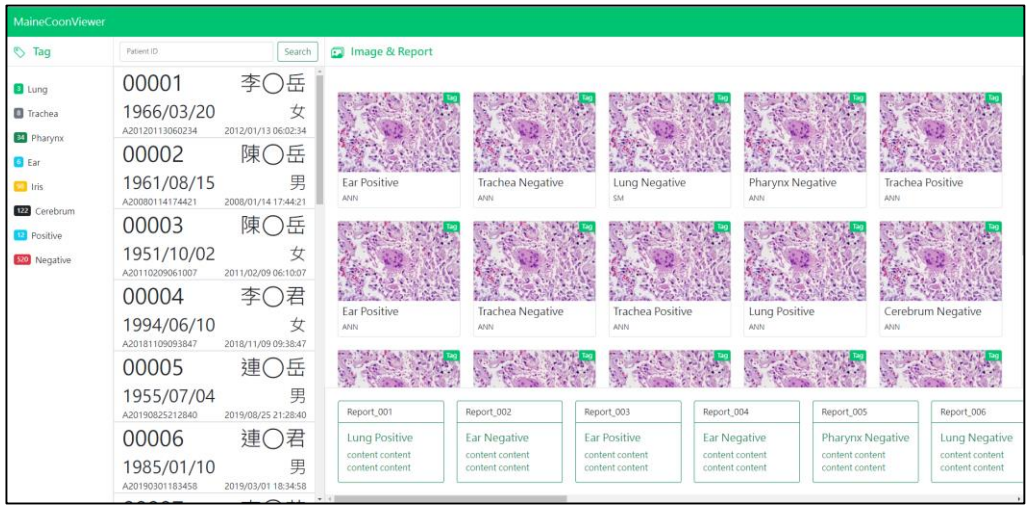
Ting Kuo

We are open source, DICOM, IHE and FHIR compatible.

Future works

- We are developing the open-source tools for management and viewing the FHIR Report with DICOM image to build the pathology imaging research repository.

https://github.com/cylab-tw/



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