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International Telecommunication Union
Standardization Sector

Recommendation

ITU-T H.861.0 (V2) (01/2024)

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E-health multimedia systems, services and applications – Multimedia e-health data exchange services

Requirements on communication platform for multimedia brain information

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Recommendation ITU-T H.861.0 (V2)

Requirements on communication platform for multimedia brain information

Summary

Recommendation ITU-T H.861.0 (V2) describes a conceptual ecosystem intended to exchange brain data based on communication platform requirements and definitions. Starting from a background of brain data exchange in the context of e-health, a functional framework model for a multimedia brain information platform (MBI-PF) is outlined. This model is then developed into a set of communication platforms which enable not only experts but also non-experts to utilize brain data for monitoring and maintaining health status of the brain.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
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Keywords

Brain, e-health, metadata, MRI, permission, rights information.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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1 Scope

This Recommendation describes requirements for exchanging multimedia brain information (MBI). This Recommendation primarily considers information provided by magnetic resonance imaging (MRI) because it has advantages of having very high spatial resolution in non-invasive techniques of brain study. The brain information provided by other techniques is beyond the scope of this Recommendation.

NOTE – Other techniques for handling brain information include electroencephalography (EEG), near infra-red spectroscopy (NIRS) and magnetoencephalography (MEG).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T H.861.1] Recommendation ITU-T H.861.1 (2018), *Requirements on establishing brain healthcare quotients*.

[ITU-T Y.3501] Recommendation ITU-T Y.3501 (2016), *Cloud computing – framework and high-level requirements*.

[ISO 12052] ISO 12052:2017, *Health informatics – Digital imaging and communication in medicine (DICOM) including workflow and data management*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 availability [b-ISO/IEC 27000]: Property of being accessible and usable on demand by an authorized entity.

3.1.2 cloud computing [b-ITU-T Y.3500]: Paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand.

NOTE – Examples of resources include servers, operating systems, networks, software, applications, and storage equipment.

3.1.3 cloud service [b-ITU-T Y.3500]: One or more capabilities offered via cloud computing (3.1.2) invoked using a defined interface.

3.1.4 communication platform [b-ITU-T T.180]: Consists in a number of communication service providers, in a homogeneous access mechanism, by means of which service users, which are distributed in space, may establish communication between them.

3.1.5 confidentiality [b-ISO/IEC 27000]: Property that information is not made available or disclosed to unauthorized individuals, entities, or processes.

3.1.6 information security [b-ISO/IEC 27000]: Preservation of confidentiality (3.1.5), integrity (3.1.7) and availability (3.1.1) of information.

NOTE – In addition, other properties, such as authenticity, accountability, non-repudiation, and reliability can also be involved.

3.1.7 integrity [b-ISO/IEC 27000]: Property of accuracy and completeness.

3.1.8 personally identifiable information (PII) [b-ISO/IEC 29100]: Any information that (a) can be used to identify the PII principal to whom such information relates, or (b) is or might be directly or indirectly linked to a PII principal.

NOTE – To determine whether a PII principal is identifiable, account should be taken of all the means which can reasonably be used by the privacy stakeholder holding the data, or by any other party, to identify that natural person.

3.1.9 service provider [b-ITU-T M.1400]: A general reference to an operator that provides telecommunication services to customers and other users, either on a tariff or contract basis. A service provider may or may not operate a network. A service provider may or may not be a customer of another service provider.

NOTE – Typically, the service provider acquires or licenses content from content providers, and packages this into a service that is consumed by the end-user.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 brain healthcare quotient: A numerical indicator representing physical characteristics of the brain that are purported to be indicative of some state of a health-related condition.

3.2.2 imaging: A technique and process of visualization of the internal parts of the brain.

3.2.3 intervention: An action or activity undertaken to address a specific client problem and to improve, maintain or restore health, or to prevent illness.

3.2.4 magnetic resonance imaging: A medical imaging technique used in radiology to investigate the anatomy and physiology of the body in both health and disease.

3.2.5 multimedia brain information platform: A platform for exchange information and data concerning the brain such as MRI data.

3.2.6 non-invasive: Medical procedures where no tools that break the skin or physically enter the body are involved.

3.2.7 spatial resolution: The ability of an imaging system to discriminate between two adjacent high-contrast brain objects.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BHQ	Brain Healthcare Quotient
DICOM	Digital Imaging and Communication in Medicine
EEG	Electroencephalography
fMRI	functional Magnetic Resonance Imaging
MBI	Multimedia Brain Information
MEG	Magnetoencephalography
MICCS	Medical Imaging Cloud Communication and Knowledge System

MIP	Medical Informatics Platform
MRI	Magnetic Resonance Imaging
NIRS	Near infra-red spectroscopy
PII	Personally Identifiable Information

5 Conventions

The following conventions are used in this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

Requirements are identified using the following conventions:

– Requirement number xx in clause n.m is of the form R-xx;

– Recommended requirement number yy in clause n.m is of the form RR-yy;

– Optional requirement number zz in clause n.m is of the form OR-zz.

6 Background

Brain and neurological disorders, including neurodegenerative and psychiatric diseases, currently affect millions of people and represent enormous economic costs, and improvements in preventive measures are considered to be an immediate social need.

In order to provide methods to prevent and treat these disorders, acquisition and accumulation of neurological brain-related information has been progressing worldwide. Devices, especially MRI, for measuring brain and neurological functions are becoming more and more popular, and it is expected that the availability of brain-related information will grow globally.

Neurological brain-related information, however, is currently stored in limited sites and locations, such as special hospitals and universities, and since policies for collecting informed consent depend on each location, together with economic considerations, a liberal use of neurological information is often avoided, and as a result, brain information is not shared among the various stakeholders with diverse objectives that may be able to ameliorate the above dire situations. The advancement in sharing of brain information, on the other hand, is expected to lead to development of products and services that prevent the onset of neurological and brain disorders, alleviating the consequences of such disorders economically and socially.

Thus, though there is a large potential in the utilization of brain information, its value has not been fully enjoyed by society as a whole.

6.1 Usage of brain information

Brain information taken with MRIs can be divided broadly into the following two categories:

1) using an MRI, the structural and morphological information of the brain can be visualized;

2) using an MRI, changes in cerebral blood flow can be detected and brain activity status can be visualized.

With this information, not only brain disorders, but also the health status of the brain related to the prevention of such brain diseases can be predicted.

6.2 Distribution of brain information

The advancement of sharing brain information is seen to be hindered by the lack of the following:

- interoperable platforms for exchanging information among hospitals that treat patients with disorders, and preventive institutions that collect data from healthy individuals so that prevention, as well as treatment, of brain-related disorders is enabled;
- sound ethical guidelines for the sharing of brain information among organizations and individuals;
- mechanisms for managing brain information when sharing among different organizations, e.g., with different levels of permissions and restrictions on the kind of information shared, etc.

Since these call for global cooperation and interoperability, there is an urgent need to advance international standardization on the above aspects.

6.3 Key items for standardization

The following issues need to be resolved in order to promote circulation of brain information in society as a whole:

a) Information access:
   - it is difficult to discover what kind of brain information exists and where it is located because management processes of brain-related information are not globally standardized;
   - because of the lack of standardized formats on informed consent for the usage of brain information, it is hard to confirm details of permission: the range of the information to be disclosed, users to be authenticated and authorized to access, and purpose of the usage.

b) Information exchange:
   - exchange processes of brain-related information are inefficient and time-consuming because a common communication method does not exist.

c) Information browsing and editing:
   - data formats of stored brain information are often expected to be browsed by experts only; therefore, it is not easy for everyone else to use the information;
   - it is necessary to analyse combined data consisting of various information and brain images in order to edit brain information. There is no standardized specification of metadata format.

NOTE – The term "editing" in this Recommendation means obtaining new brain information by conducting various analyses of original brain images such as scoring of cognitive function or fatigue degree of brain.

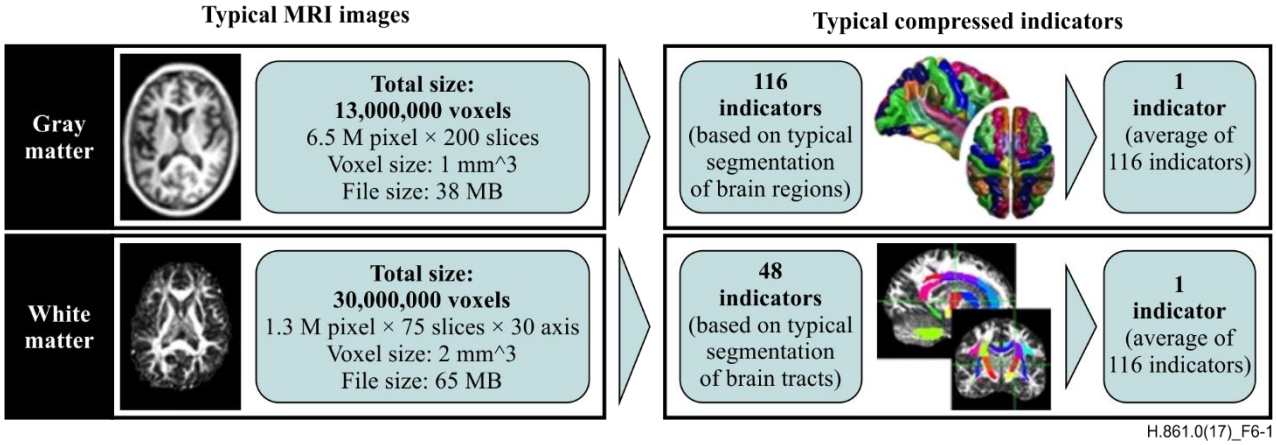
Accordingly, for realizing sound and well-managed sharing of brain information and its effective utilization, the following are key standardization items, among others:

- communication interface and protocol to exchange brain information;
- identity (ID) management and permission control to allow access to the brain information, according to certain ethical guidelines;
- (multimedia) data and metadata formats.

6.4 Examples of formats of brain data

Brain information obtained by MRI is often represented as brain images in a digital imaging and communication in medicine (DICOM) format [ISO 12052]. Data size per brain image and the number of images are different from the kind of features a brain user wants to know (e.g., brain volume, neural tract). The total size of original images is often so large that only experts can conduct them. However, through brain imaging analysis, these images can be compressed to brain health indicators, i.e., brain healthcare quotient (BHQ), which are useful for non-experts to use. See [ITU-T H.861.1] and Figure 6-1 below.

Further examples can be found Appendices III, IV and V.



NOTE – Voxel refers to a unit of graphic information that defines a point in three-dimensional space.

Figure 6-1 – Examples of typical MRI images and compressed indicators

7 Exchange of multimedia information of the brain

7.1 Basic concepts of the MBI communication platform

Figure 7-1 illustrates a communication platform for MBI. The MBI platform (MBI-PF) provides three main capabilities: access, exchange, browse and edit, to enable persons to freely utilize brain information, all over the world, in the same way that web services are used through the Internet.

The MBI platform consists of the following two ecosystems, whose purposes are different from each other:

1) one system aims to enable the grasp of current brain conditions; and
2) another system tries to keep brain healthcare in the future.

Users of the MBI platform are classified into three types:

1) a general customer who lives on;
2) specialists or organizations working on analysis of brain health status; and
3) specialists or organizations relevant to intervention methods for brain healthcare.

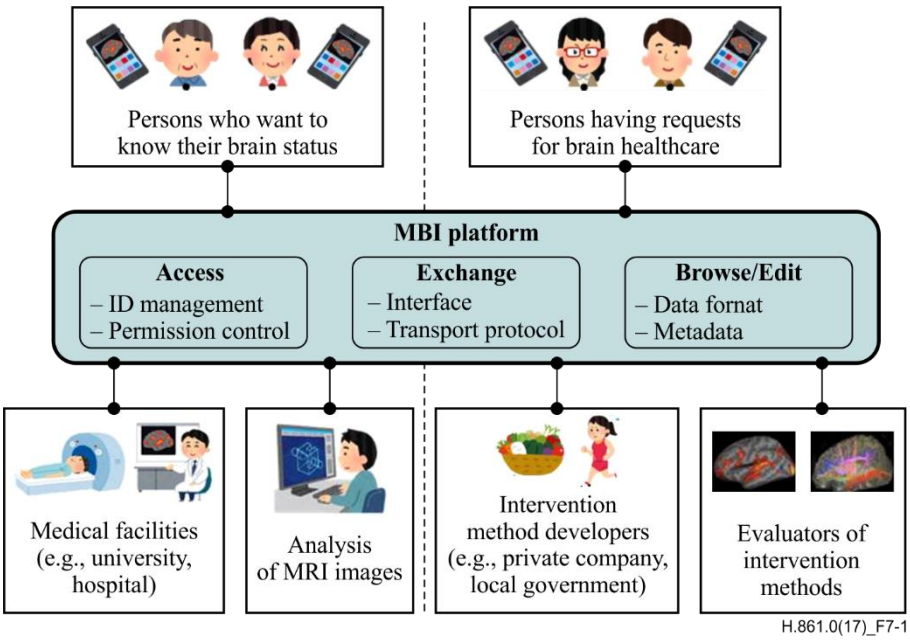


Figure 7-1 – Illustration of an MBI platform

7.1.1 An ecosystem for multilateral analysis of brain status

The MBI platform creates relationships among users, and contributes to realizing ecosystems which enable users to perform multilateral analysis of brain information and to comprehend brain status (see left side of Figure 7-1). The platform offers users its services as follows:

- MRI data holder: a person who holds his/her MRI data, and sets conditions and the span of the data set to access. The data holder requests to perform analysis of brain images in order to multilaterally understand their brain health status.
- Medical facilities that perform MRI imaging: facilities (e.g., a university, a hospital, an examination institution) which take and manage individual MRI images and relevant information. These facilities, on behalf of the data holder, monitor brain health status and offer specific services based on the results of the monitoring.
- Analyst of MRI images: supporting staff for data analysis, uses an image analysis application in the MBI platform. The staff evaluates and analyses brain information and provides the results of the analysis as requested by the data holder.

7.1.2 An ecosystem for intervention methods for brain healthcare

The MBI platform creates relationships among users, and realizes ecosystems which enable users to obtain information about intervention methods for brain healthcare or enable service-relevant persons to create the methods (see right side of Figure 7-1). The platform offers users its services as follows:

- MRI data holder: can obtain information on a variety of intervention programs for preventing brain disease according to the holder's brain data.
- Developers of intervention methods: entities (e.g., a private company, a local government) create the hypothesis of an intervention method, support research and development of the method, and verify the effect of the method by accessing and using brain information.
- Specialists of statistical analyses of the intervention: supporting staff who examine the results of intervention programs. These specialists can implement a statistical analysis application in the MBI platform. The specialists can access brain information and provide the results of the analysis as requested by the data holder.

7.2 Capabilities of the MBI platform

The MBI platform provides users with the following three main capabilities to enable them to freely utilize brain information globally to:

1) access brain information;
2) exchange brain information; and
3) browse and edit brain information.

7.3 Functional framework for the MBI platform

See details in Annex A.

8 Requirements

Requirements for a multimedia brain information platform service are described in the following clauses.

8.1 General

The platform offers users MBI services of brain status analysis based on the following requirements:

- R-1: MBI platforms are required to have the capability to authenticate and authorize users to access data through the platform according to access permissions for the usage of brain information;
- R-2: MBI platforms are required to have the capability to either perform data analysis of brain images or exchange intervention program among users;
- R-3: MBI platforms are required to have the capability to accept requests for data analysis from the data holder;
- R-4: MBI platforms are required to provide a way to offer results of the data analysis to the data holder;
- RR-1: MBI platforms are recommended to support both data analysis of brain information and intervention programs;
- RR-2: MBI platforms are recommended to have the capability to enable users to implement image analysis applications and/or statistical analysis applications.

8.2 Access

8.2.1 ID management

ID management enables users to clearly distinguish attributes of the brain information: the type of image, the name of the programme, the name of the institution where the imaging was conducted, the institute-specific user ID, and the time and date of the imaging.

- R-5: Brain information is required to be assigned a unique ID and managed with this ID to avoid scattering or being inaccessible to the information.

8.2.2 Permission management

Disclosure conditions are set based on the discretion of the holders of the brain information and imparted to each of individual brain information. Specific disclosure conditions (e.g., unconditional, chargeable, provision of useful information) are set for each target (e.g., enterprises, hospitals) of the brain information disclosure.

- R-6: MBI platforms are required to have the capability to set access permissions consisting of disclosure conditions according to the type of user;

- R-7: MBI platforms are required to allow MRI data holders to set the access permissions.

8.3 Exchange

8.3.1 Transmission protocol

- R-8: The hypertext transfer protocol (HTTP) is required to be used for the communication of brain information from (the) platform to end-users;
- R-9: Transaction descriptions are required to be described by extensible markup language (XML).

8.4 Browsing

8.4.1 MRI data format

Researchers often use special formats specific to medical images, such as MRIs, such as DICOM.

NOTE – Neuroimaging informatics technology initiative (NIfTI-1) data format [b-NIFTI] is also a well-known data format for functional MRI data analysis.

It is also important to consider the case where concerned persons, other than researchers, browse and use brain information.

- RR-3: MRI data are recommended to be formatted as analysable to non-experts (e.g., regional brain volume value).

8.4.2 Metadata format

A combination of various kinds of detailed data is usually requested for analysis of brain information.

- R-10: Metadata formats are required to be applicable to diversified data which are arranged according to users' requests.
- R-11: Metadata formats for the MBI-PF are recommended to be applicable to indicate health level of the brain using a format such as BHQ. See [ITU-T H.861.1].

8.5 Security

[ITU-T Y.3501] addresses general requirements for cloud computing. The following requirement on information security of cloud computing is applicable to services provided through the MBI platform.

– R-12: It is required that the cloud computing environment be appropriately secured to protect the interests of all persons and organizations involved in the cloud computing ecosystem.

There are public security-regulations regarding medical/healthcare services based on the circumstances of each country. Specifically, personally identifiable information (PII) should be carefully treated in the field of medical/healthcare relevant services.

– R-13: MBI platforms are required to obey public security-guidelines established by a national/local government or an authorized agency.

NOTE – Several reference guidelines are introduced in Appendix II.

Annex A

Functional framework for the MBI platform

(This annex forms an integral part of this Recommendation.)

The platform functional architecture framework shown in Figure A.1 identifies the principal functional groups of an MBI platform. The following clauses give a description of each functional group.

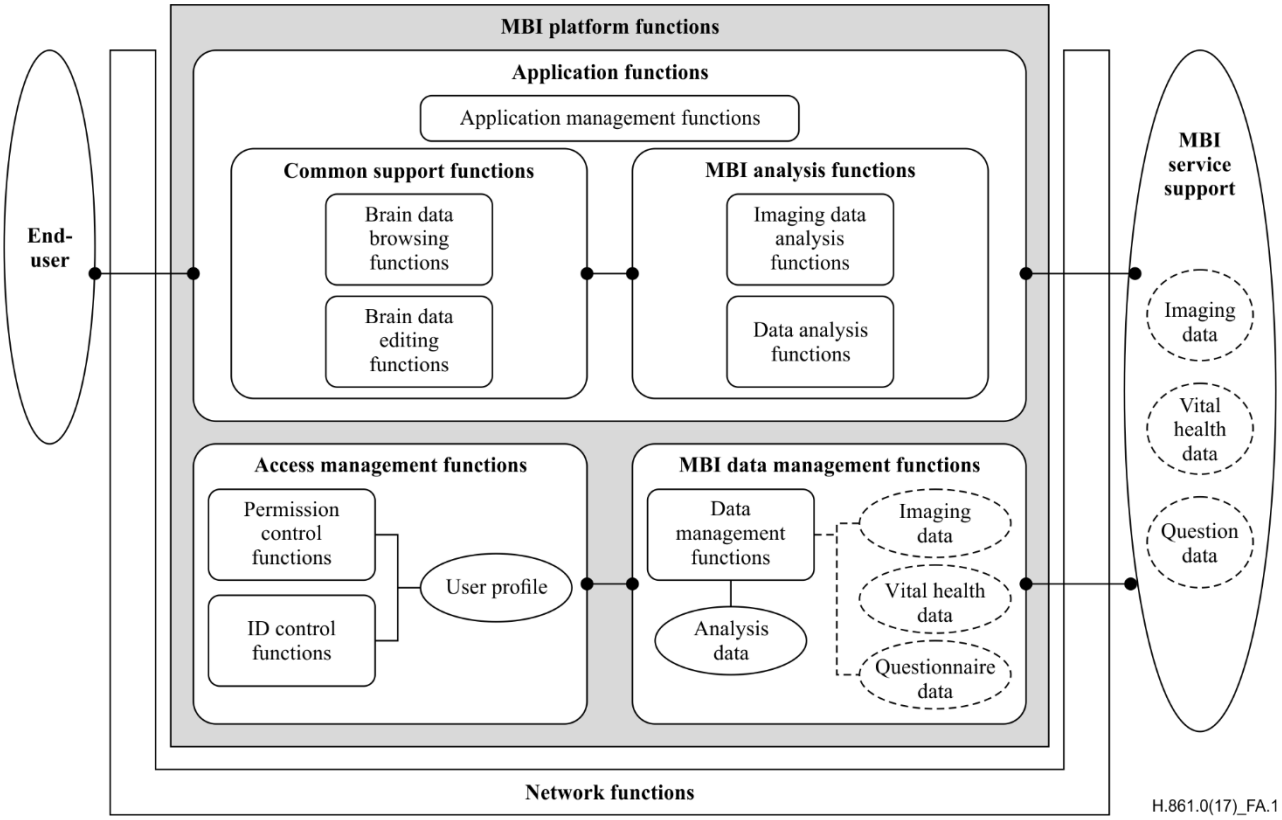


Figure A.1 – Functional framework for the MBI platform

A.1 Users of the MBI platform

There are two types of users of the MBI platform.

A.1.1 End-user

This entity is a person, who holds the brain information, consumes the service of brain information analysis and/or intervention programs through the MBI platform.

A.1.2 MBI service support

This entity contains, e.g., medical staff, medical organizations, MBI analytical specialists and intervention method developers.

A.2 Application functions

The application functions provide users of the MBI platform with functions to browse and analyse data.

A.2.1 Application management functions

When receiving requests from users, application management functions perform relevant applications, which interact with MBI data management functions and access management functions to use MBI information on the MBI platform.

A.2.2 Common application functions

This functional group provides common functions to users of the MBI platform.

A.2.2.1 Browsing functions

Browsing functions interact with MBI data management functions to retrieve and display brain data.

A.2.2.2 Editing functions

Editing functions provide the functions for users to select an analysis application of MBI data analysis functions and to get additional information of brain status.

A.2.3 MBI data analysis functions

A.2.3.1 Imaging data analysis functions

The imaging data analysis functions include applications for brain volume analysis, physical network analysis, functional connectivity analysis.

A.2.3.2 Data analysis functions

The data analysis functions include applications for analysing relations between brain data and vital health data or questionnaire data.

A.3 Access management functions

The access management functions perform authentication and authorization to access services and data within the MBI platform.

A.3.1 ID management functions

ID management functions interact with users and provide the functions to specify a unique ID for brain data.

A.3.2 Permission management functions

Permission management functions interact with users and provide the functions to manage access permission information. This information is also used for MBI data management functions to control access to MBI information.

A.3.3 User profile

This is a database that stores detailed information of users and service permissions.

A.4 MBI data management functions

The MBI data management functions receive MBI data including brain images from the application functions. The functions store and supplementally process the data under control of the access management functions.

A.4.1 Imaging data management functions

Imaging data management functions provide the ability to store MRI imaging data.

A.4.2 Data management functions

Data management functions provide the ability to manage and store MRI image data, vital health data and questionnaire data in the platform. The data may be located in and imported from the MBI service support.

A.4.3 Imaging data

Imaging data includes brain data acquired by MRI.

A.4.4 Vital health data

Vital health data includes a person's health data objectively captured by wearable devices (e.g., fitness monitor, jogging monitor, sleep monitor, heart rate monitor and sphygmomanometer). These data also includes the data aggregated as online behaviour (e.g., behaviour on social network services).

A.4.5 Questionnaire data

Questionnaire data includes psychological data that is difficult to be directly captured by physical measures including wearable devices (e.g., psychological health status, housing environment, working environment.)

A.4.6 Analysis data

The result of data analysis is stored in the platform.

A.5 Network functions

The network functions provide IP layer connectivity between the end-user and the MBI service support and MBI platform functions.

Appendix I

A practical use-case: illustrative brain healthcare service models

(This appendix does not form an integral part of this Recommendation.)

Appendix I describes typical service models of the MBI-PF. This Recommendation can be used for storing and exchanging data regarding the health status of a person's brain. By integrating brain imaging data and the various data of daily life through the MBI-PF, a service provider can analyse cause and effect relationships between the health status of one's brain and lifestyle. These analyses can create useful information for brain healthcare services listed below.

Service model A

See left side of Figure I.1.

After acquiring a user's brain imaging data, a service provider firstly searches the database of brain images to detect the health status of the user's brain. Next, by searching (and analysing) the cause of the health status, through the integrated data of brain images and various data of daily life, the service provider is able to give the user information on what kind of lifestyle can be recommended to improve the health status of the user's brain.

Service model B

See right side of Figure I.1.

After acquiring various data about a user's daily life, a service provider searches (and analyses) the effects of it, through the integrated database, which can estimate the health status of a user's brain without having the original brain imaging data.

Service model C

By combining service model A and service model B, a service provider can recommend lifestyle changes for improving the health status of the user's brain.

Service model A can be regarded as the personalised e-health service [b-ITU-T H.810] for predicting brain health. Service model B and C can be regarded as the service for visualizing the health status of a user's brain without expensive medical equipment (e.g., MRI), which can also be associated with universal health coverage promoted by the World Health Organization (WHO) [b-WHO-UHC].

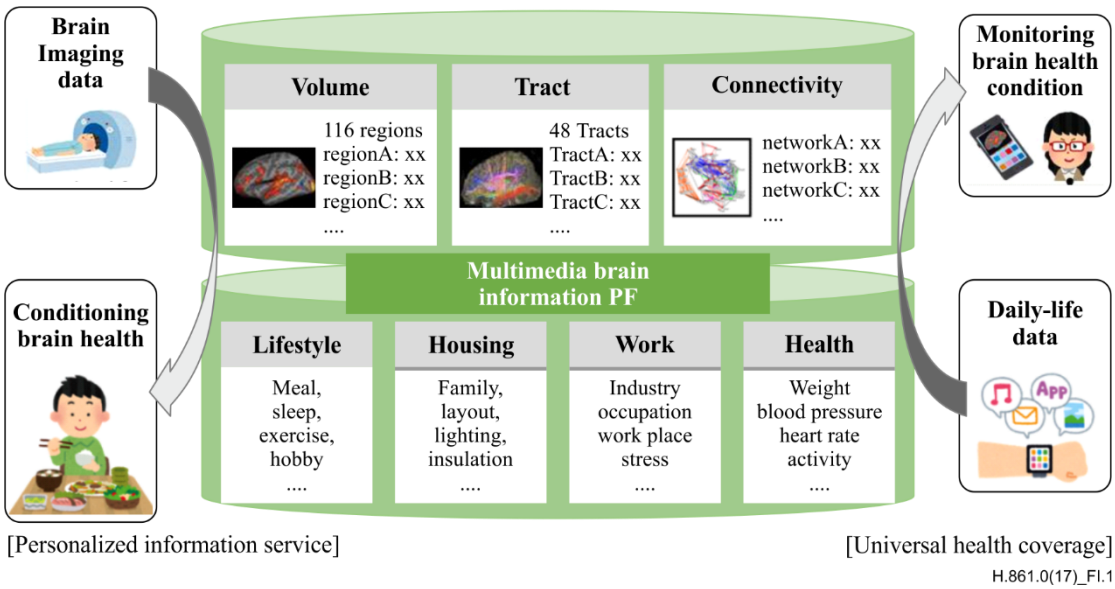


Figure I.1 – Illustrative brain healthcare service models

Appendix II

References for security guidelines of MBI platform

(This appendix does not form an integral part of this Recommendation.)

This clause introduces security guidelines, which are created based on the circumstances of each country, of the usage of medical/healthcare services through the platform.

II.1 Examples of security guidelines

This is for future study.

Appendix III

An example of MBI platform: MICCS

(This appendix does not form an integral part of this Recommendation.)

III.1 General overview of MICCS

This appendix describes medical imaging cloud communication and knowledge system (MICCS), an example of a multimedia brain information platform, a cloud-based platform for storing information about the brain (MRI and associated data).

Figure III.1 gives a rough diagram describing MICCS.

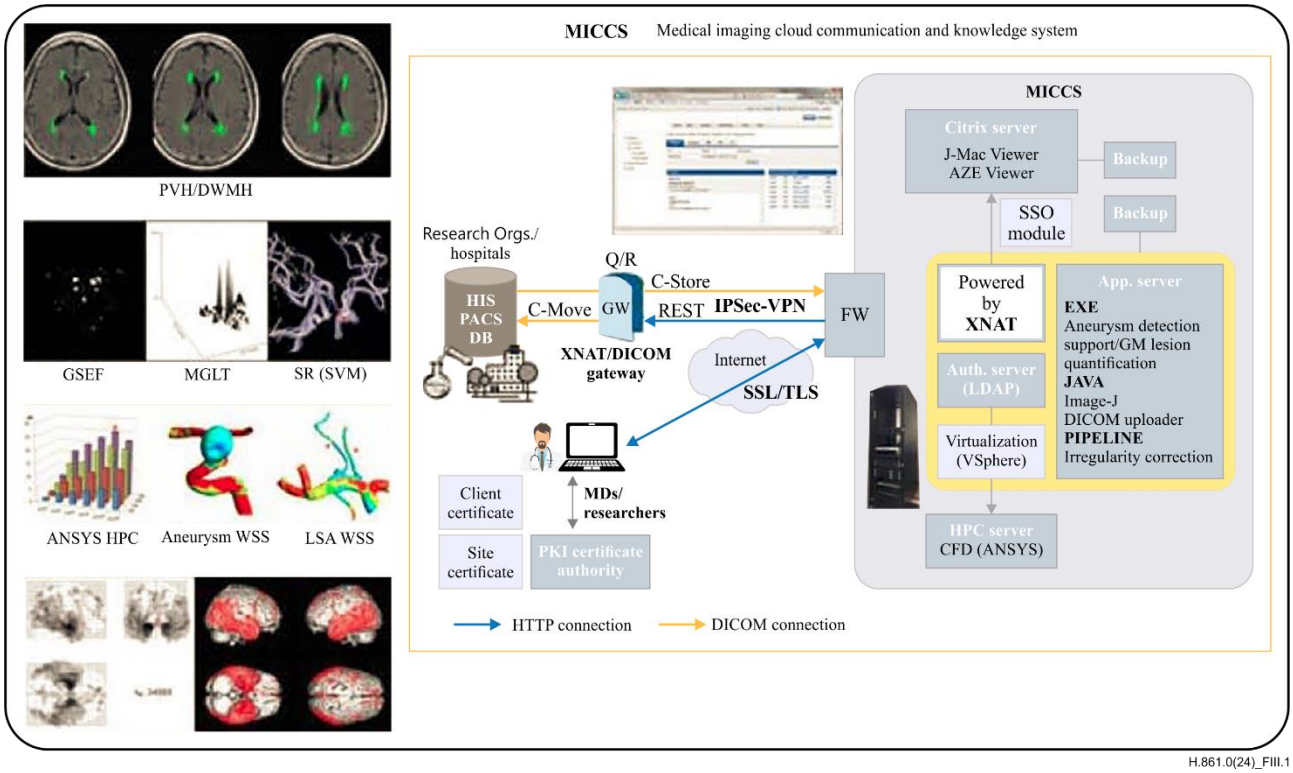


Figure III.1 – MICCS

MICCS was first developed at an academic site for diagnostic support applications. XNAT program was customized, and the effectiveness of the pipeline engine and access control was confirmed. To develop a scalable and secure platform, the service flow of diagnostic support and guidelines for secure management of healthcare information technology were examined. The operation was confirmed by building a verification site that was defined by a 17-system infrastructure. Finally, diagnostic support services deployed on the verification site were evaluated using XNAT, and countermeasures were developed for the extracted problems.

MICCS has two programs that automatically extract an unruptured cerebral aneurysms and asymptomatic white matter hyper intensities from magnetic resonance imaging (MRI) data as components of the quantitative analysis application for asymptomatic intracranial lesions in elderly subjects. In addition, a DICOM viewer running on a desk-top virtualization platform, high performance computing systems for fluid dynamics analyses, and pipelines for voxel-based morphometry are implemented as a stroke prediction support system for asymptomatic cerebrovascular and brain lesions.

MICCS can support and be connected to brain dry-dock facilities.

Appendix IV

An example of MBI platform: MIP

(This appendix does not form an integral part of this Recommendation.)

This appendix describes medical informatics platform (MIP). MIP is a platform for neuroscientists and clinicians. This platform bridges research with clinic by building biological signatures of diseases from research data and validating it on hospital clinical data. Technology platform co-developed with hospital-IT experts and clinicians received positive feedback from additional clinical users. Experience and expertise in clinical trial, image-analysis, techniques and applied machine learning to transform medical data into "actionable" features for research.

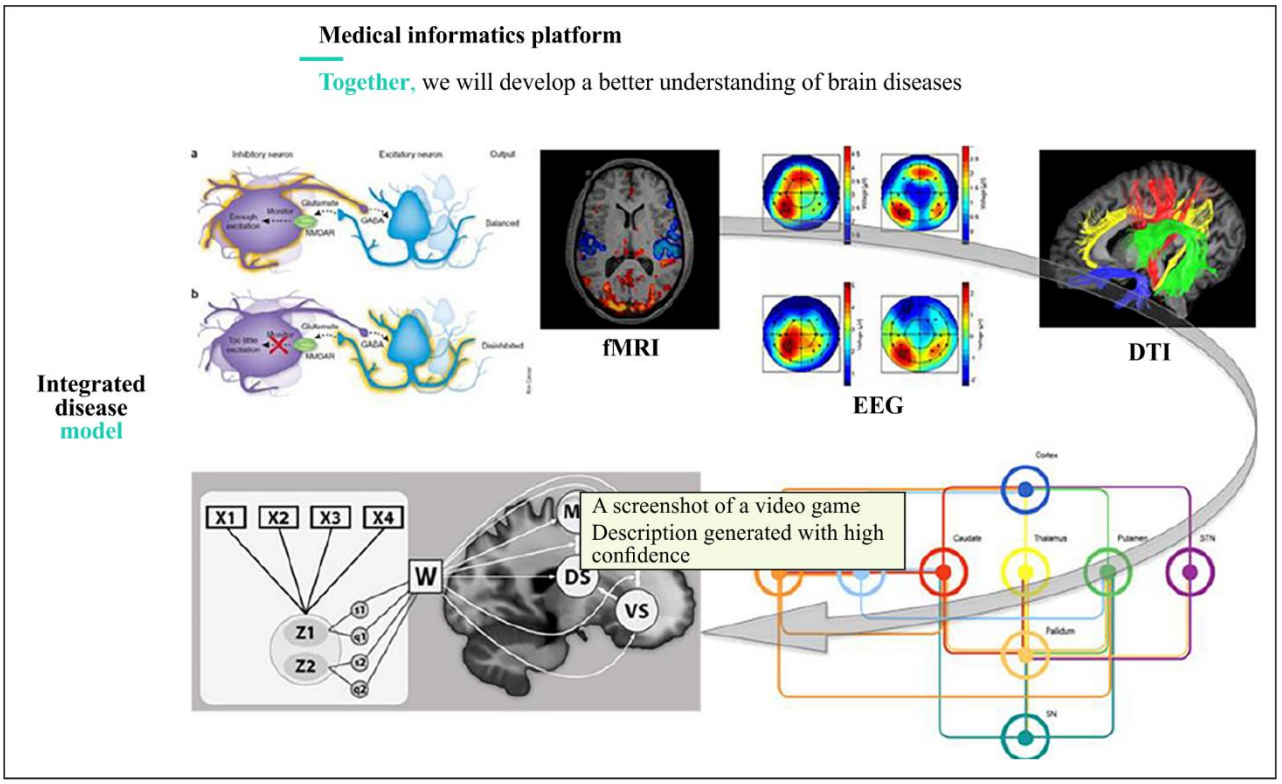


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Figure IV.1 – Overview of MIP

MIP collects data from hospitals, analyses it and provides to our community. This opens new doors to the understanding of the brain.

The hospitals can use and contribute to the MIP by making their data available to the advanced computing analysis tools. Data is not moved, copied or transferred.

The entire architecture is built around ethics considerations: the data captured in each care centre is only made available to the algorithms for advanced statistical computing analysis. Users connect to the MIP through a web portal with a user-friendly interface.

Appendix V

An example of MBI platform: XNAT

(This appendix does not form an integral part of this Recommendation.)

XNAT is an open source imaging informatics platform developed by the neuroinformatics research group at Washington University. XNAT was originally developed in the Buckner Lab at Washington University, now at Harvard University. It facilitates common management, productivity, and quality assurance tasks for imaging and associated data. Thanks to its extensibility, XNAT can be used to support a wide range of imaging-based projects.

XNAT has a browser-based interface for its functions. Specific functions are provided as a Java applet or as an external program.

XNAT supports the following functions:

Upload data

XNAT supports a variety of methods to upload data, including importing DICOM image data and metadata directly from scanners; customizable forms for direct entry of clinical or psychometric data; and ZIP-enabled uploaders for archived data of all kinds.

Organize and share data

All data stored in XNAT is associated with a user-defined project. This association is the basis of the XNAT security model: Users are given access to data on a project-by-project basis.

Download and view data

XNAT includes an online image viewer that supports a number of common neuroimaging formats, including DICOM and analyse. The viewer can be extended to support additional formats and to generate custom displays.

Securing and managing access to data

XNAT enables quality control procedures and provides secure ways to access data and control its accessibility. XNAT follows a three tiered architecture that includes a data archive, user interface, and middleware engine. Data can be entered into the archive as XML or through data entry forms. Newly added data are stored in a virtual quarantine called the Pre-archive until an authorized user has validated it. XNAT subsequently maintains a history profile to track all changes made to the managed data.

User access to the archive is provided by a secure web application. The web application provides a number of quality control and productivity features, including data entry forms, data-type-specific searches, searches that combine across data types, detailed reports and listings of experimental data, upload/download tools, access to standard laboratory workflows, and administration and security tools.

Search and explore large data sets

XNAT generates a usable web interface which allows you to store, retrieve, navigate and query data which corresponds to the data structures that are most important to users.

Data processing pipelines

XNAT includes a pipeline engine that allows for the programming of complex workflows with multiple levels of automation.

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