# How to Identify and Assess Tasks and Challenges of Medical Image Processing

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**Abstract**

*Research in Medical Image Processing (MIP) is mainly driven by a technology-oriented point of view. However, as an application-oriented field, MIP research should always be able to give an answer to the question of what is the potential benefit of a solved MIP problem or a newly developed MIP-based system supporting a diagnostic or therapeutic process, in terms of outcome criteria like e.g. Quality Adjusted Life Years (QALYs) for the patient or cost savings in health care. As one subtask of establishing a Reference Image Database for MIP R&D Groups, the Working Group on Medical Image Processing of the European Federation for Medical Informatics (EFMI WG MIP) works on an answer. This paper presents the concept and the strategy of how the Most Relevant MIP problems (MRMIP) shall be identified and assessed in the context of improving evaluation of MIP solutions.*

***Keywords:***

Medical Image Processing; tasks and challenges.

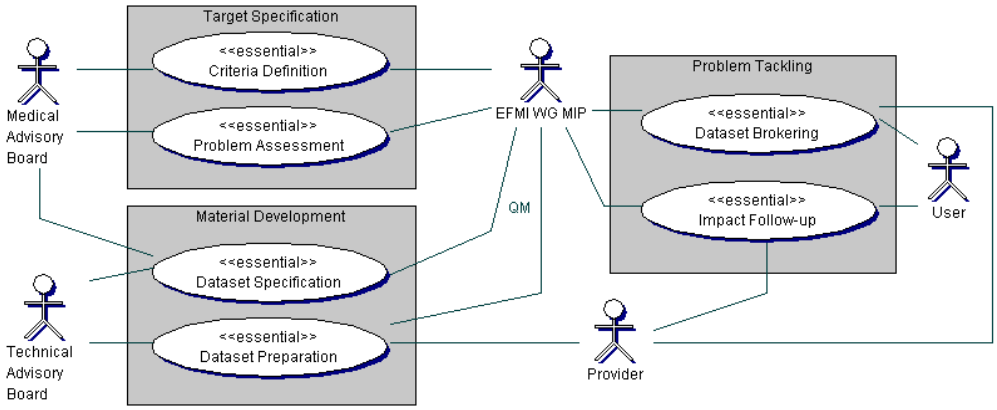


*Figure 1: The context: business processes of RID-MIP initiative*

## 1. Introduction

The field of Medical Image Processing (MIP) and the applications in Computer Assisted Diagnoses (CAD) and therapy (e.g. Computer Assisted Surgery – CAS) which strongly depend on MIP methods are of increasing importance in modern medicine [1][3]. Nevertheless, due to its proximity to medical imaging devices, the field is widely considered as an engineering discipline with a methodological progress that is somehow independent from medical problems and the clinical practice. Even if this might be correct for basic research on domain-independent image processing methodology, it is surely wrong if one emphasizes on system research and development meant for support of diagnostics and therapy.

While there is an ongoing broad discussion about evidence-based medicine, in which decisions are made on the basis of reliable knowledge about efficacy and – not less important on the background of the big problems in financing the healthcare systems – also about efficiency, the MIP field seems to be more or less resistant against the question about the impact of produced progress on medicine and healthcare in general.

But what are the most relevant MIP problems to be solved in terms of their impact on support of major problems in medicine and modern healthcare? So far, no comprehensive attempts have been undertaken to clarify this important question. As one subtask of establishing a Reference Image Database for MIP R&D Groups [4][5](figure 1), the Working Group on Medical Image Processing of the European Federation for Medical Informatics (EFMI WG MIP) [2] has decided to work on an answer. This paper describes the concept and strategy of how such relevant MIP problems shall be identified and assessed in the framework of the working group.

## 2. Definitions, Material and Methods

Some essential notions have to be defined for usage in the context of this paper.

A *challenge* is an exact description of a work objective for which no real ideas and methods are present how to find a solution, whereas a *task* is an exact description of a work objective for which paths to build solutions already exist. Both kinds of descriptions shall be called *problem*.

A medical problem shall be called a *Most Relevant Medical Problem* (MRMP), if its solution would have a high impact on the overall health status of people and/or on the efficiency of producing/sustaining health at a certain quality level.

In the context of imaging, the important notion of *Medical Image Interpretation* (MII) is introduced as denoting the process of deriving medically relevant information from analyzing a medical image or a set of images. MII can be performed either by the physician (visual assessment) or by a MIP application (computer assessment), or in a combination of both (usually as computer-supported assessment by the physician).

As material for the process planning, all kinds of actual statistics and literature have been used. The Unified Modeling Language (UML) has served as method for working out the concepts and depicting the different aspects of the assessment task.

## 3. Results

Starting with the description of the business processes form the context of the approach, assessment criteria are defined and a model of the assessment process is presented. The outcome of carrying out the assessment according to the model shall not be anticipated, but at least a guess of how it could look like shall be given in the end of the section.

### 3.1 The Context

Figure 1 shows the overall context in which the assessment takes place: the business processes of the EFMI WG MIP initiative for establishing a Reference Image Database (RID) for MIP Research & Development (R&D) groups. There are three main blocks: 1) the Target Specification Block, defining highly relevant MIP problems; 2) the Material Development Block, creating task-specific reference data (mainly image datasets) to perform MIP R&D for solving such a problem; 3) the Problem Tackling Block, comprising the dissemination of problems and datasets (briefly "Dataset Brokering", emphasizing on the image data) as well as the follow-up, i.e. documentation and assessment of the impact of the brokering on the R&D results, mainly to be measured in terms of publications (briefly "Impact Follow-up").

### 3.2 Criteria Definition

In order to specify highly relevant tasks and challenges, the following criteria for to measure relevance are used:

1. Relevance of medical problem in terms of
   a. Mortality & morbidity statistics
   b. Cost statistics
   c. DRG statistics (USA, Australia, Austria, etc)
   d. Funding by independent organizations (WHO, EC, etc)
   e. Current scientific activities (institutions, projects)
   f. Literature

   Using these criteria, it will be decided and argued which medical problems shall be considered as MRMPs.
2. Role of imaging and MII in the diagnostic and therapeutic process:
   a. Key role
   b. Important role
   c. Marginal role
3. Potential for outcome improvement by more accurate MII in terms of
   a. Outcome criteria (e.g. Quality Adjusted Life Years, QALYs)
   b. Cost savings

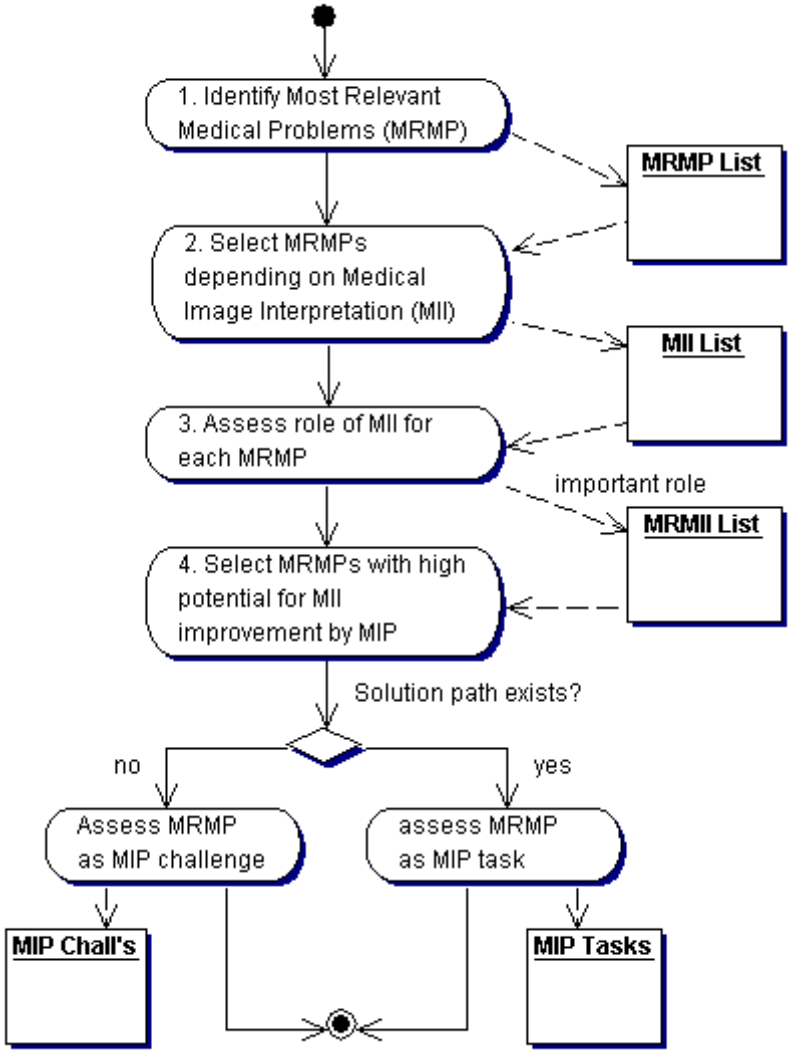


*Figure 2: Problem assessment process and results*

### 3.3 Problem Assessment

The problem assessment process, as depicted in figure 2, comprises the following major steps: After the identification of the current MRMPs (step 1, generating a list of MRMPs) and the selection of those which involve MII (step 2, creating a list of MII-dependent MRMPs, briefly: "MII List"), the role of MII within the current evidence-based practice applied to these problems has to be identified and evaluated (step 3). If this role is at least an important one (if not even a key role), the MRMP is considered a Most Relevant MII-dependent MRMP (MRMII) and added to a respective list (briefly "MRMII List"). Next, the potential for improving evidence-based practice by means of (better) MIP methods/applications for the improvement of the MII parts of the process has to be estimated in terms of appropriate outcome variables (step 4). Up to this point, there are no "mental scissors" in the assessment process with respect to any technical feasibility of MIP support to a MII problem. Only now, in the last step (step 5), the MRMII problems are classified in challenges and tasks, i.e. state of the art in MIP research is taken into account.

The decision whether (the idea of) a solution path exists or not, i.e. whether a MIP problem has to be considered as a task or as a challenge, is essentially based on literature and the quality of available systems/prototypes, e.g.: number of published approaches tackling a problem (none, few, many); quality of published solutions/methods (from heuristic to model-based, degree of automation); quality of results from existing systems/prototypes (accuracy, universality, robustness). If there cannot be found neither any fairly satisfactory solution nor a 'convincing' approach for how to build such a solution, then the problem shall be considered a challenge.

### 3.4 First guess

A search in literature gives a first guess of where the most relevant MIP tasks and challenges probably have to be expected (see Table 1).

By current MIP research activities and in MIP literature a couple of medical problems are frequently addressed as highly MII-dependent, and therefore as offering a high potential for significant improvement through usage of MIP methods. Concerning diagnosis and therapy control, such problems are e.g. screening (mamma, skin, cervix), melanoma (early) diagnosis, coronary diseases, cell detection, tumor (early) detection, lesion classification, tumor staging, responder problem in chemo/radiation therapy and cerebral activation (fMRI). As to treatment, there are e.g. (accurate) treatment planning (surgery, radiation therapy, thermo therapy), design and fitting of implants and intra-operative tracking.

## 4. Discussion

An assessment strategy for identifying and classifying MIP problems has been presented. Theoretically, the suggested assessment process seems straight-forward: Adjusting the parameters in the criteria (thresholds for numbers of publications, inclusion and exclusion criteria for clinical trials, etc) and collecting the necessary statistics, the process becomes operational. However, it has to be observed, that the available material will certainly not be comprehensive enough for to cover all important problems. Furthermore, the practical definition and application of the criteria will to some extent always be descriptive and consent-based.

## 5. Conclusion

Even if the practical carrying-out of the assessment process will not always be possible without a certain portion of uncertainty due to missing information, it can be hoped that it will nevertheless help in setting the right priorities where to put the main efforts within the RID-MIP

initiative of EFMI WG MIP and foster awareness of MIP professionals for the important question of relevance.

*Table 1: Total number of meta-studies on diagnostic imaging referenced in Medline database on June 5, 2002, sorted by frequency*

| # | **Diagnosis** | **Procedure** |
|---|---|---|
| 25 | Breast tumor | Mammography |
| 17 | Coronary disease | Coronary angiography |
| 16 | Breast tumor | Screening |
| 11 | Myocardial infarction | Coronary angiography |
| 9 | Coronary disease | Echo cardiography |
| 9 | Coronary disease | Exercise tolerance test |
| 8 | Coronary disease | Prognosis |
| 6 | Relapse | Coronary angiography |
| 6 | Coronary disease | Echo cardiography |
| 6 | Coronary disease | Single Photon Emission Tomography (SPECT) |
| 6 | Coronary disease | Computer Tomography (CT) |
| 6 | Myocardial infarction | Outcome |
| 5 | Female Infertility | Hysterosalpingography (HSG) |
| 5 | Pulmonary_Emboly | Computer Tomography (CT) |
| 5 | Pancreatitis | Retrograde endoscopic cholangiopancreatography |
| 5 | Heart Disease | Echocardiography |

## 6. Acknowledgements

The authors want to thank the members of EFMI WG MIP for fruitful discussions around the topic.

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