to be considered crucial for the advancement of MCV towards a scientific discipline in a strict sense. Lessons to be learned e.g. from physics clearly indicate that a theory-empiricism/experiment cycle is the foundation of a scientific discipline, put provocatively or even bluntly: Experiments in MCV without having a computational theory to be falsified are rather useless.

Apart from these rather heretical remarks, as one down-to-earth-consequence of the weak experimental basis of CV it is by no means clear for an industrial system designer on which grounds she/he should rely on a particular algorithm, method, or tool proposed in the literature once she/he is faced with the problem of putting academic research to work. Neither does it seem to be clear for a clinician both what kind of and what degree or even quality of computational support in his daily work she/he can expect from proffered MCV tools claimed to support routine work. Though the plethora, not to say cornucopia, of scientific publications is impressive, only little or even almost none is available in terms of data and spec sheets good engineers can draw upon. Put in other words, MCV seen as a coin has a shiny and scientifically rewarding theory side - but a rather rusty experiment and practice side.

Meanwhile in both the CV and the MCV community a growing awareness of the fact can be observed that evaluation aiming at performance characterization is a critical issue. Accordingly from both clinical and industrial actors a strong need for tackling theoretical as well as experimental problems associated with the issue of evaluation has been stated, since dissemination of theoretical MCV advances into practical settings requires a deep understanding of assets, limitations, application scope, etc. of MCV theories, algorithms, approaches, methods, and tools. In this context generic methods which are on the one hand theoretically and experimentally well-understood, on the other hand applicable e.g. to various domains and widely independent of a specific imaging modality or of image class characteristics are a desideratum not just only from a research perspective. Interestingly, it is also safe to state that without such a thorough understanding gained from a stringent scientific approach the human-centred design of interactive systems will be severely hampered. User-friendly, cognitively adequate, effective, and efficient user interaction with medical imagery should be based upon results of computational processes which are as-trustworthy-as-achievable - in the ideal case: digital results being fully consistent with theoretical proofs of an underlying continuous computational theory. Such a consistency on the other hand is also the key to the certification of an implementation which is a critical issue since MCV stands out for reasons of required safety, accuracy, speed, robustness, ergonomy, etc. - thus a large number of partially even conflicting requirements have to be met.

Apart from that, on an international scale MCV is also seen as a major future high-tech market hence the development of successful products strongly depends on bridging the gap between theory, experiment, and practice. Obviously, solutions to this problem reside in a space composed of multiple dimensions, to name a few: MCV theory, practice of MCV (incl. design of algorithms and visual data structures), experimental methodology, clinical requirement analysis, and industrial platform constraints. Owing to the lack of well-grounded, internationally accepted, and standardized methods for evaluation and given the briefly sketched specifity of MCV, it seems to be high-time to spur trans-disciplinary discussions about which road(s) to be jointly taken in the near future by academic research, medicine, and industrial R&D.

3 Some roads to be taken in the next millenium (in brief)!

Experimental methodology as well as approaches to validation and evaluation for both performance characterization and quality assurance are scientific key topics in the context of assessing MCV algorithms, methods, tools, and systems. The general issue of assessment, in its widest sense of technology assessment, here applies to a variety of inter-related levels, e.g., the theoretical, algorithmic, methodical, experimental, technical, systemic, pragmatic, applicative, ergonomic, and economic level. Since it is impossible to tackle the plethora of open problems with adequate breadth and depth until the end of the current millenium, setting priorities is essential for the purpose of contributing towards a seamless methodology of validation, evaluation, and performance characterization across the various levels – thus contributing also to bridge the gap between MCV theory and the medical end user.

In terms of short- and mid-term priorities, focus should be set on the following intertwined concrete topics: i) requirement analyses w.r.t. clinical, methodical, and technical aspects of MCV, ii) theoretical analyses of computational theories and algorithms, iii) combination of MCV and interactive system paradigm, iv) investigation of theoretical and methodological issues of experimental MCV (incl. terminology), v) realization of certified test image data bases composed of clinical reference cases (incl. WWW accessibility), vi) development of internationally standardized experimental test beds along with practicable evaluation procedures, benchmarks, and performance measures, vii) definition of compulsatory ad-minimum requirements for papers in experimental sections of scientific publications.

Since these topics are of a scientific, clinical, industrial, and societal nature, nationally concerted actions (e.g. priority research programs) have to be undertaken on the one hand while on the other hand inter-/trans-disciplinary "under-one-roof? research groups are indispensable for reasons of efficacy (a lesson already learned, e.g., at the Image Sciences Institute of Utrecht University and the Computational Imaging Science Group of King's College London). From a long-term strategic perspective, prioritizing and funding of MCV research is also tightly coupled to questions related to general health care issues. First, which clinical disciplines for application of MCV and which anatomical domain to choose for which reasons and, second, which class of system to design and realize for which types of user groups and associated tasks. Apart from the simple fact that a demonstrated need for computational support in a particular discipline and of the involved medical experts has to be extant, findings from epidemology and evidence-based medicine have to be taken into consideration as well, which in turn has to go hand in hand with prophylaxy - otherwise the status quo of medicine might be frozen in by a purely technocratic approach through high-tech armament alone.

Evidently, given all these challenges, it is indispensable i) to exchange knowledge and visions across disciplinary and institutional borders to establish new working modes between theory and practice and ii) to rethink the current division of labor between academic researchers, clinical experts, health care system professionals, and industrial actors. Seen in such a light of a systemic, or even holistic, approach, MCV is rather close to a crossroad - the roads to choose are, to name a few, phenomenology, l'art pour l'art, technocracy, or science for serving mankind.

Contact
H. Siegfried Stiehl, Prof. Dr.-Ing.
Universität Hamburg, FB Informatik, AB Kognitive Systeme
Vogt-Kölln-Straße 30, D-22527 Hamburg, Germany, E.U.
E-Mail: stiehl@informatik.uni-hamburg.de
URL: http://kogs-www.informatik.uni-hamburg.de

H. Siegfried Stiehl received his Dr.-Ing. degree from the Dept. of Computer Science at TU Berlin in 1980 (with a dissertation on model-based brain CT analysis). After his habilitation in computer vision (with a monograph on medical spatial image sequence understanding) in 1987, he was appointed Professor of Computer Science at University of Hamburg in 1988. He participated in the European COVIRA research consortium (1989-1994) and was in charge of the Philips-funded IMAGINE project (1996-2000). His main research interests are in computer vision, medical image analysis, computational neuroscience, and visual perception.