

ITEA if-07022

HiPiP overview

Frank van der Linden, Philips Healthcare

September 28, 2010

Overview

- **Introduction**
- **Relevance**
- **Innovation**
- **Initial results**

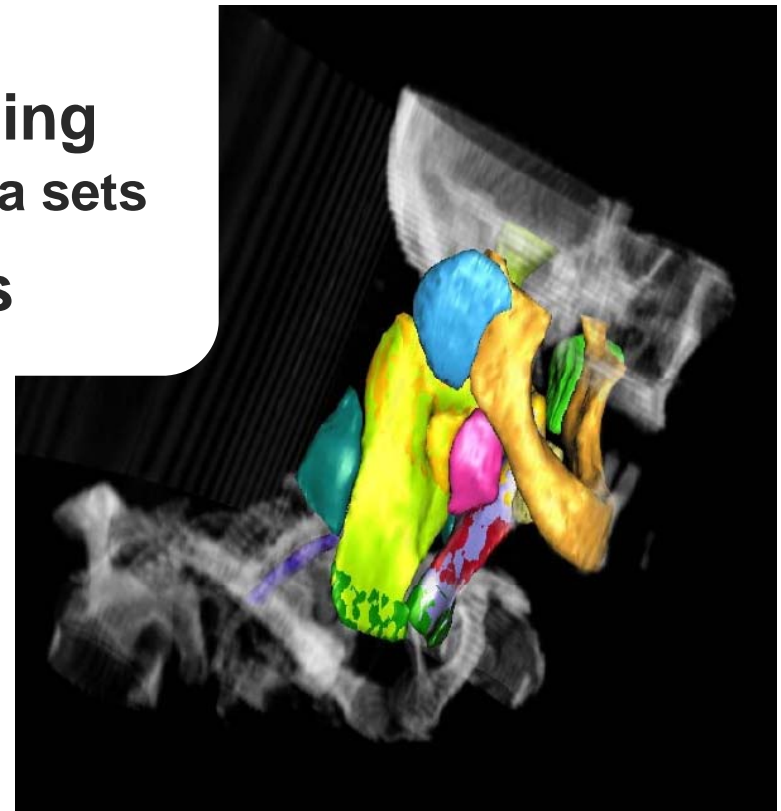


Introduction

HiPiP: Affordable parallel high-tech image processing applications

Aim

- High throughput image processing
 - Very large and heterogeneous data sets
- Shorter image-processing times
 - Detailed brain imaging
 - Minimal invasive surgery
 - Radiation therapy planning
 - Population screening
 - Faster operation of high resolution instruments



Application areas

- **Large data sets:**
 - Detailed brain imaging
 - Real-Time Simulation for radiotherapy
- **Massive throughput:**
 - Mass screening for cervix cancer
- **Real time:**
 - Minimal invasive interventions
 - Electron Microscopes



Solutions for applications, systems and networks

Image-processing parallelisation

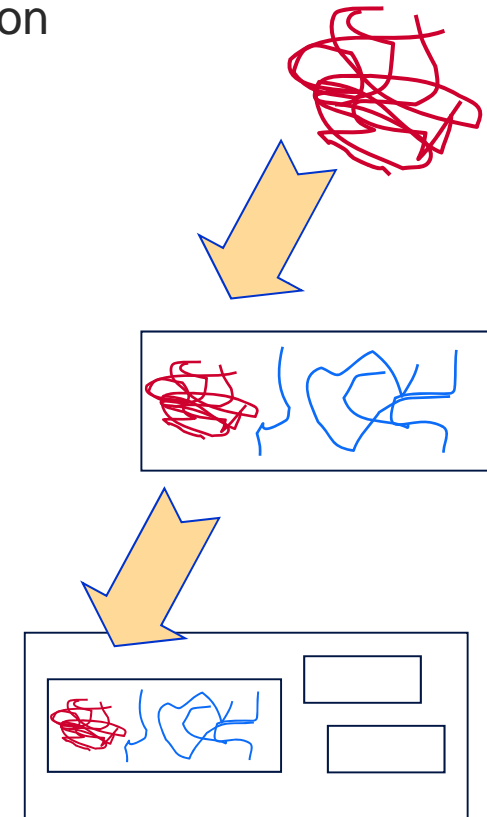
- Transforming image-processing algorithms to run on standard multi-core hardware
- Algorithm structure
- Algorithm process representation
- Resource management

Application parallelisation

- Generic system architecture
- Imaging acquisition systems
- Execution of parallel tasks
 - Real-time imaging
 - Background image archiving
 - Background image processing and reconstruction

Server-based computing resource

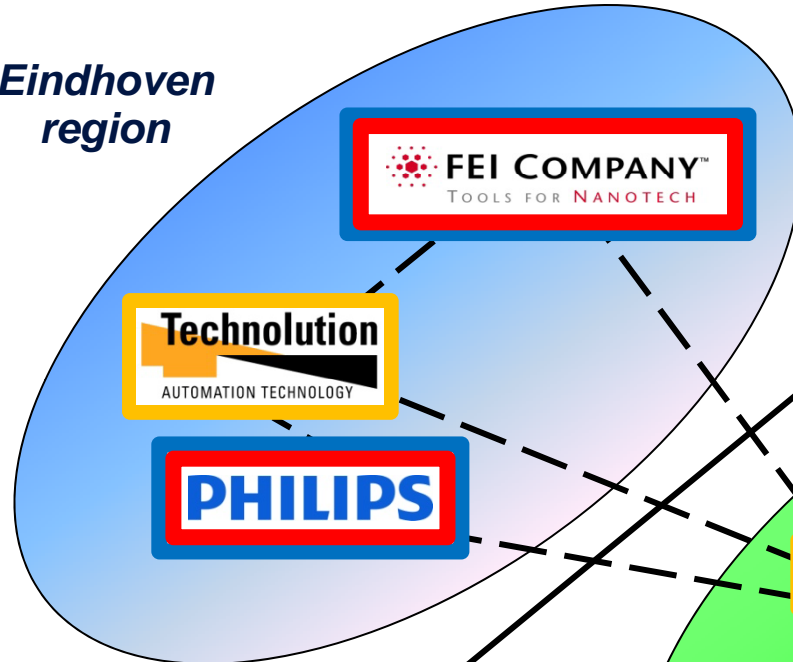
- Demonstrate feasibility
- Assess the technical limits of a
- Algorithms considering constraints of network resources



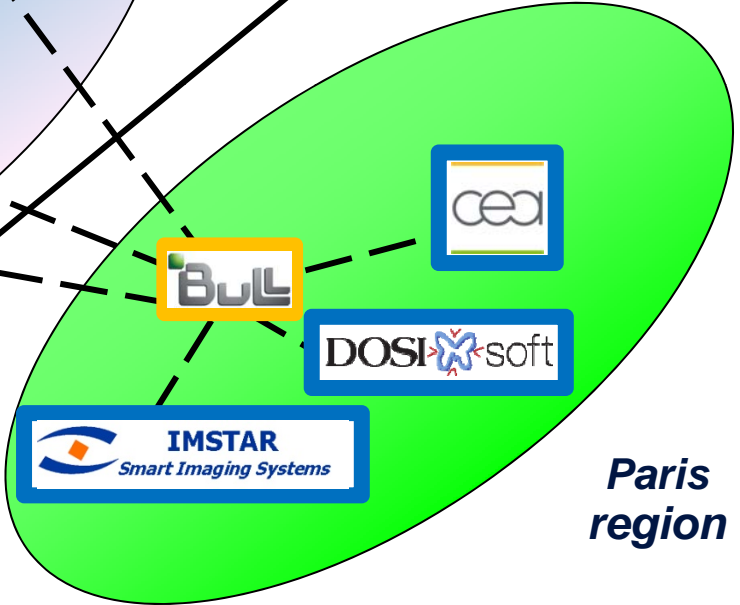
HiPiP Consortium



Eindhoven region



Paris region



- 3 Large companies
- 3 SME
- 1 Research institute



ITEA2



Overview



- Introduction
- **Relevance**
- Innovation
- Initial results

HiPiP relevance

Parallelism is becoming affordable

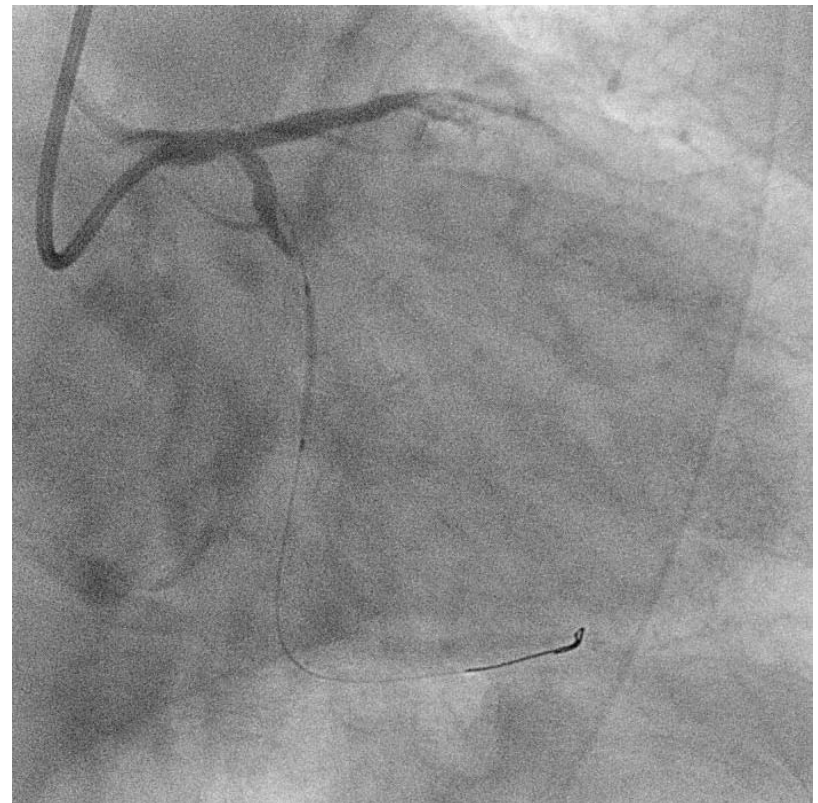
- Multi-core processors
- **But:** programming challenge

Apply for **affordable high-quality** imaging

- Medical domain
- Electron microscopy

Low latency requirements

- Real-time
- Massive throughput
- Very large data



HiPiP relevance



Multi-core processors are coming on the market

- Parallelism is becoming affordable

➤ Challenge to programming it

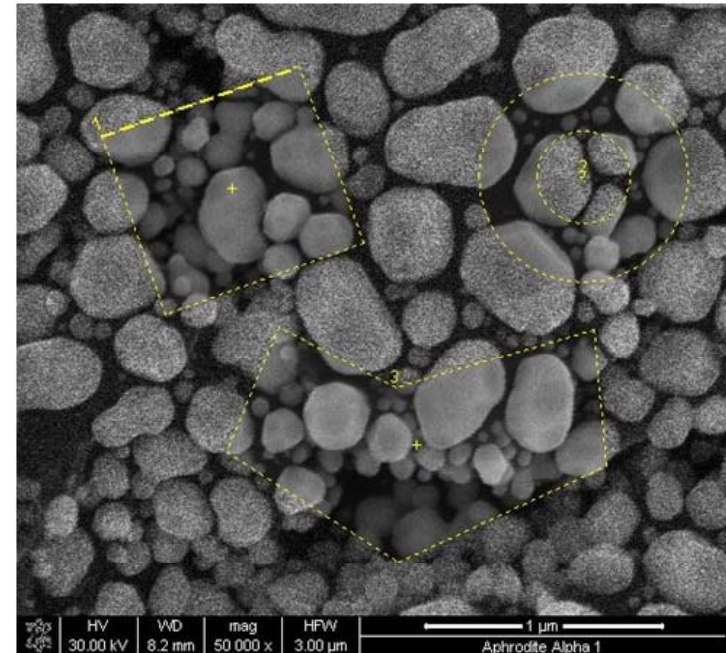
- Image processing is very complex
- Parallel solutions for present day image processing algorithms
- → options for mainstream applications

Parallel computing is of increasing importance for Europe



HiPiP overall goals

- 1. Reducing complex image-processing latency**
 - To improve immediate use of image information
- 2. High throughput image processing**
 - very large and heterogeneous data sets
- 3. Shorter image-processing times**
 - detailed brain imaging
 - radiotherapy simulation
 - cancer screening
 - minimal invasive surgery
 - high resolution instruments
- 4. Inexpensive solutions for complex tasks**
 - Solutions for applications, systems and networks

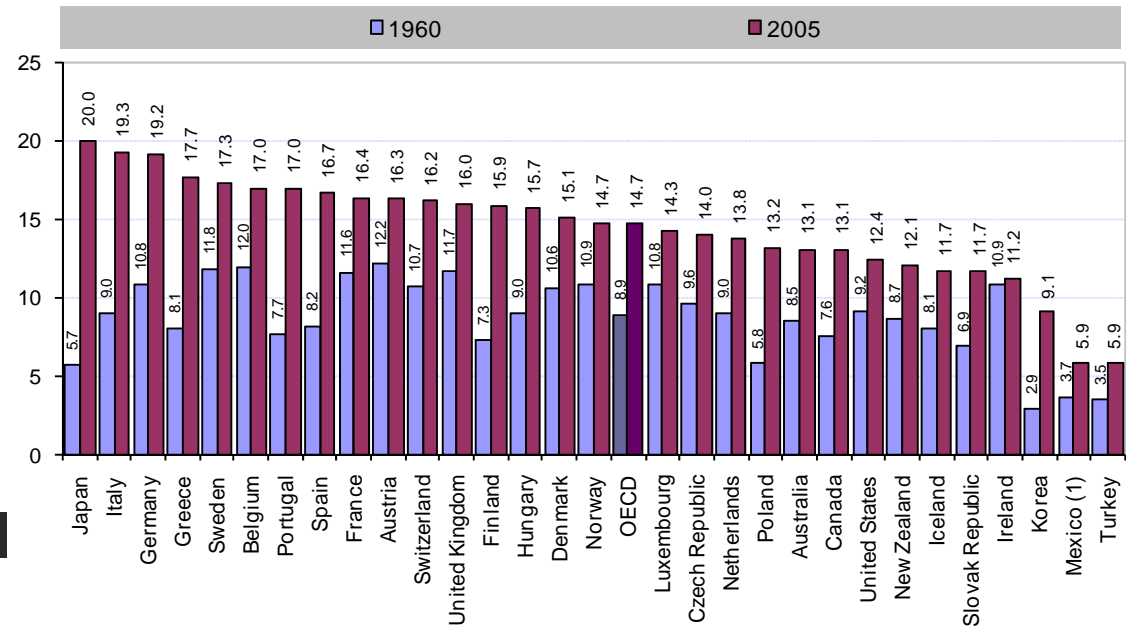


HiPiP market relevance – trends



➤ Need for medical intervention grows significantly

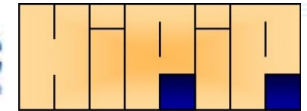
- Aging population, Current life style
- Expected growth: ~9% of worldwide GDP in 2004 to ~15% in 2020



➤ Affordable high-quality medical imaging is crucial

- Minimal invasive intervention
- Prevention of diseases from happening
- Earlier diagnostics
- Mass screening of population at high risk of cancer

Applications 1



Point-One



PHILIPS

- **Low latency imaging for minimal invasive intervention**
 - Resource management framework and algorithm parallelisation on multi-core system
 - including tool chain
 - Special attention for latency
 - Target:
 - 40% latency reduction of existing algorithms on existing hardware
 - 50% reduced effort for pipeline development and performance-tuning

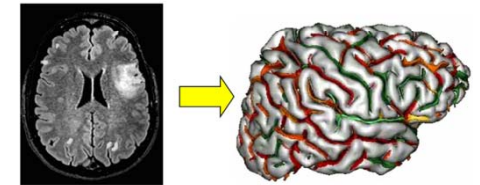
- **Dynamic PET image reconstruction**
 - Parallel standard hardware
 - drastically reducing the response time (hours) of high-resolution image reconstruction for MRI and PET
 - Target: a gain factor of 10 is expected



Applications 2

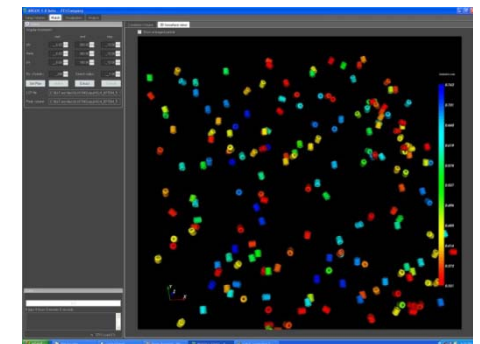
➤ Segmentation of the main brain structures and automatic sulci identification

- Reduce the computation time of comparing a whole database with a real neuro-imaging pipeline
- Current typical computation time: 12 minutes per subject
- Target : Reduce by 10 or more the time for o a database containing MRI scans of 151 subjects



➤ Automated Recognition of Geometries, Objects, and Segmentations (ARGOS)

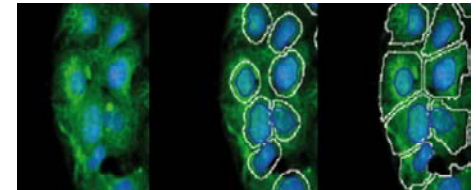
- Nanometer scale electron microscopy
- 3D template fitting capability that helps to localize macromolecules
- relate orientation properties of these molecules to their environment
- Target :
 - speed up factor ~200 on 1 CPU
 - ~3 on 54 CPU cluster



Applications 3

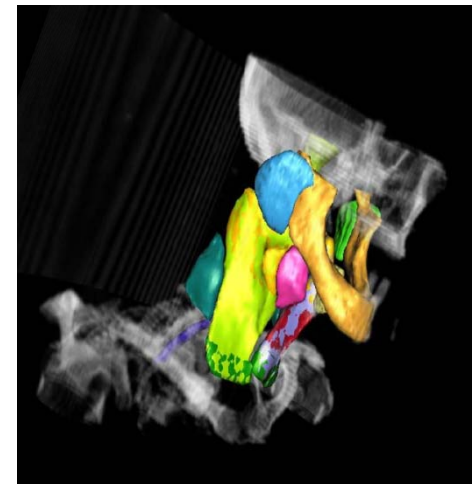
➤ Computer-assisted diagnosis

- Microscopic slide scanning platform
- Goal: continuously 24-hours-a-day scan and output
- Target: provide the effective processing speed from 6 to 1 second per view-field



➤ Virtual Simulation in Radiotherapy

- Radiotherapy virtual simulation workstation
 - capable of real time dose display
- Current: no dose display
- Target : Achieve a dose computation time less or equal to 2 seconds



Overview

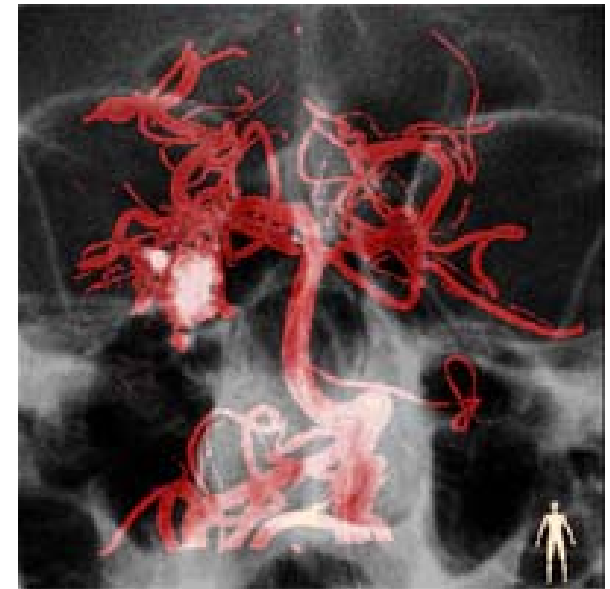


- Introduction
- Relevance
- **Innovation**
- Initial results

Improvements

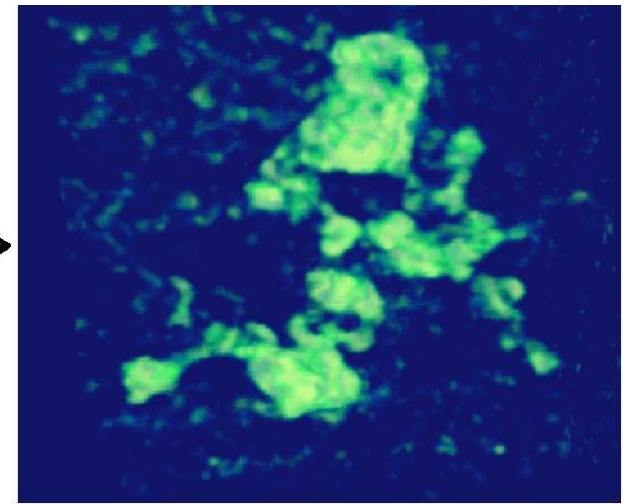
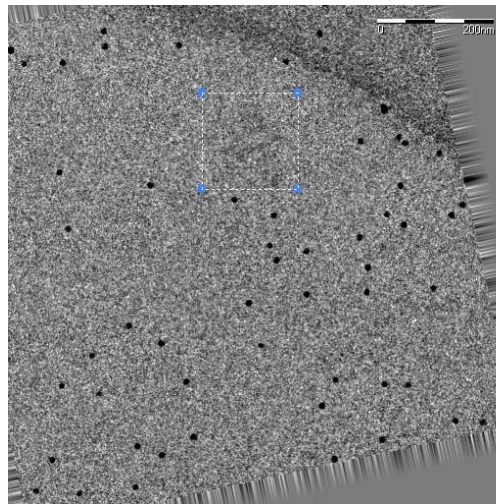
Processing of complex detailed brain images takes days

- Only applied in academic environments
 - Reduce the processing time to minutes
- **Minimal invasive interventions increasingly replace open surgery**
- Requires a large amount of fast and precise imaging
 - Real-time
- **Electron microscopes are tools to obtain high-resolution structural information on nanometer scale**
- Demand high performance image processing
 - Produce meaningful results from the vast amounts of data



HiPiP Objectives (1/2)

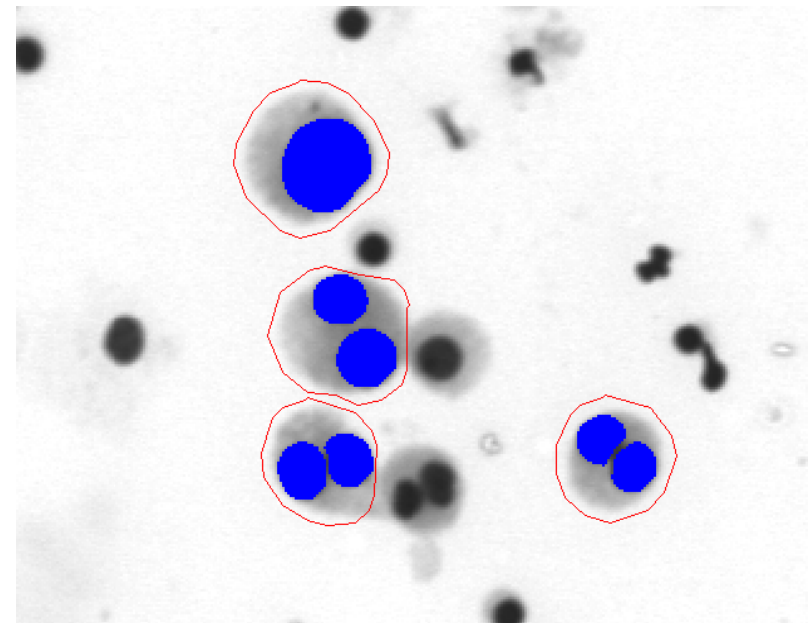
- **Reduce latency** through:
 - **Novel methods for parallel image processing**
 - improving the throughput time of algorithms
 - To real-time or low-latency procedures
 - **High throughput & shorter image-processing times**
 - **Build on experience of Bull in providing parallel solutions**
 - Currently on special hardware
 - Up to a few thousand processors



HiPiP Objectives (2/2)



- **inexpensive solutions for complex tasks:**
 - **On standard multi-core hardware architectures**
 - Affordable solutions
 - Easy to implement
 - Complex image-processing
 - Inexpensive hardware solutions



Quantified objectives – examples



➤ Latency

- 45 → 40 ms + advancing algorithms

➤ Throughput time

- 36 → 66 frames per second + advancing algorithms

➤ Reduction of X-ray dose through advanced algorithms

- 33-50% of State-of-the-Art (2009)

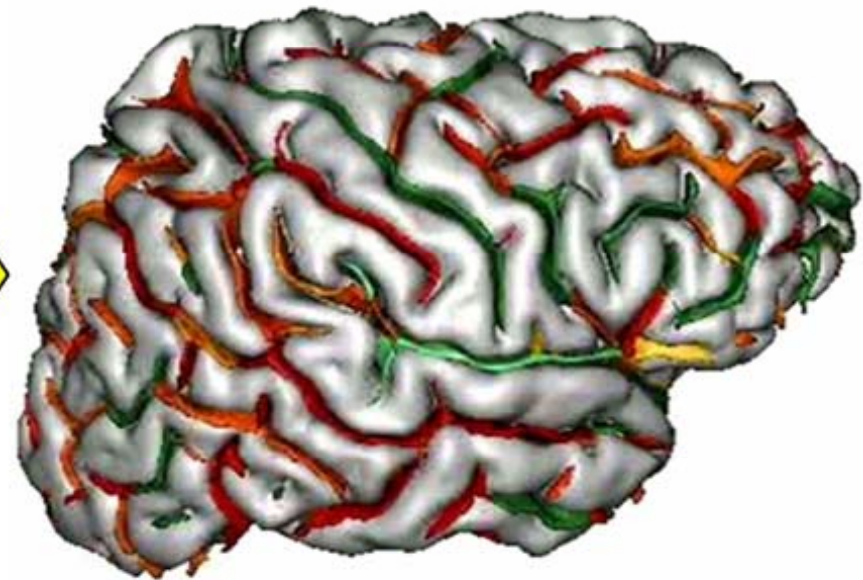
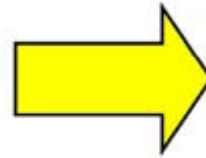
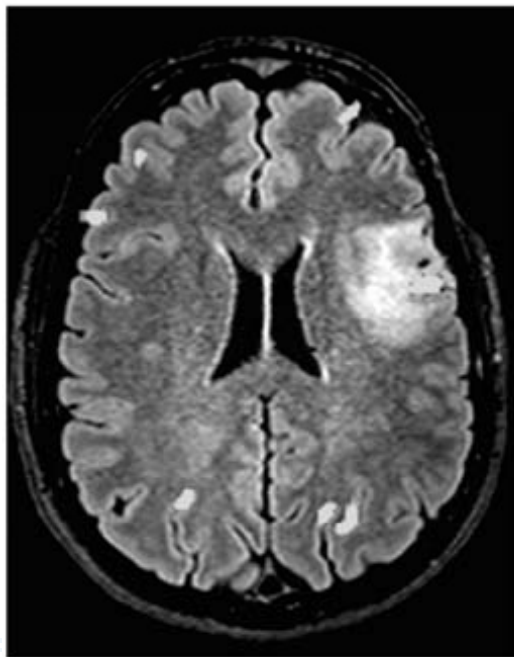
➤ Inexpensive solutions

- More performance for the same cost
- Save 5-10% on SW+HW cost with better performance
- Save development effort at system level

Parallel algorithms for complex image-processing algorithms

- Data and operation dependency
- Different scales of granularity connected

➤ Contrast to basic image-processing algorithms

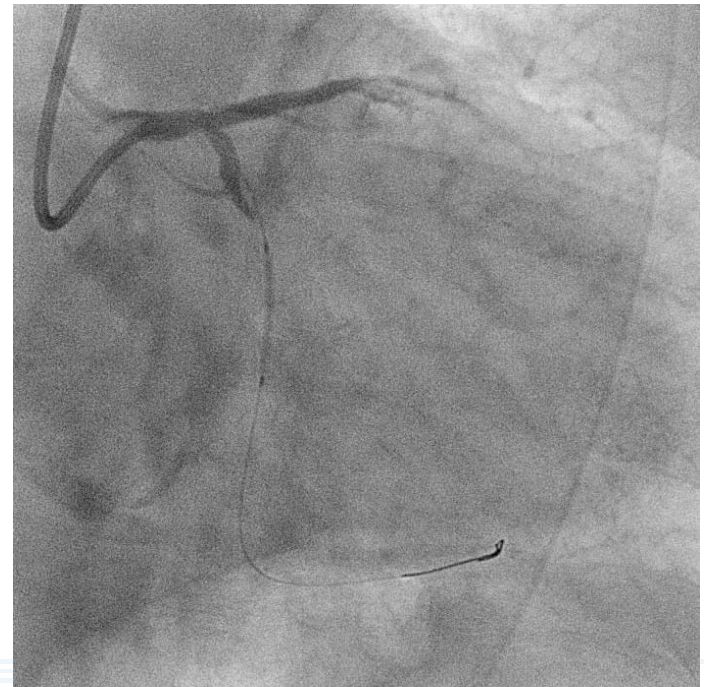


HiPiP approach (1/2)



- **HiPiP addresses complex image-processing algorithms**
 - data and operation dependency
 - different scales of granularity connected

- **Parallel solutions apply a clever mixture of**
 - Data partitioning
 - Data copying and distribution,
 - Task partitioning
 - Start tasks without all data available using clever predictions and approximations



HiPiP approach (2/2)

➤ Solutions for applications, systems and networks

• Image-processing parallelisation

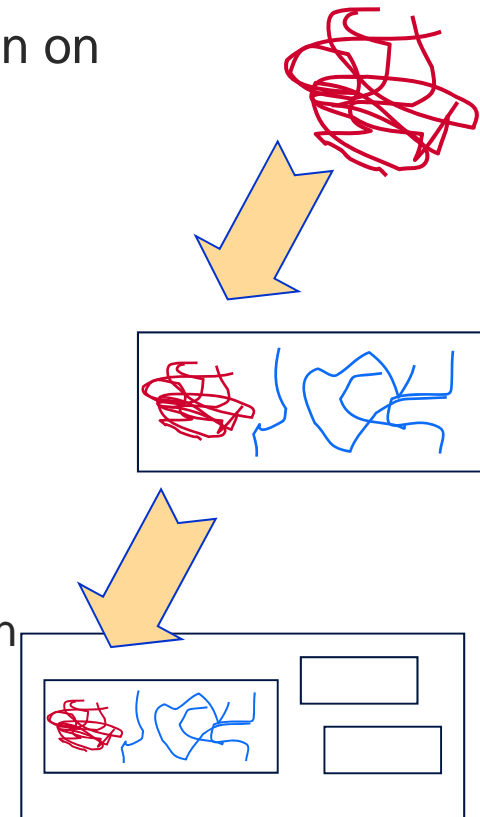
- Transforming image-processing algorithms to run on standard multi-core hardware
- Algorithm structure
- Algorithm process representation
- Resource management

• Application parallelisation

- Generic system architecture
- Imaging acquisition systems
- Execution of parallel tasks
 - Real-time imaging
 - Background image archiving
 - Background image processing and reconstruction

• Server-based computing resource

- Demonstrate feasibility
- Assess the technical limits
- Algorithms considering constraints of network resources



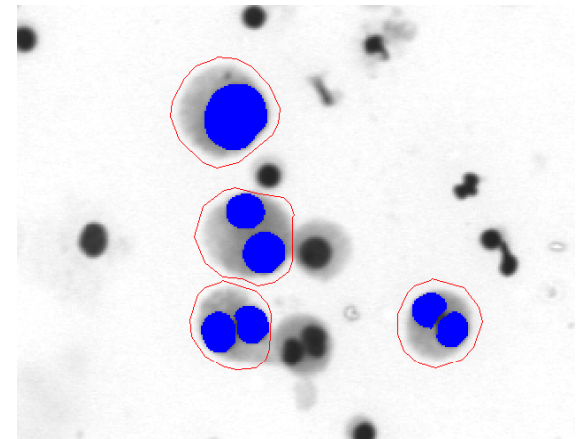
Overview



- Introduction
- Relevance
- Innovation
- **Initial results**

1st year results

- **A clear understanding of**
 - Imaging systems characteristics and needs
 - Types of parallelisation techniques
 - Algorithms and scheduling
 - Image processing parallelisation
 - First guidelines, rules, schemes & protocols
 - Tools to measure, analyse and optimise the distribution
- **An elaborate set of Image Processing use cases**
- **Virtualisation techniques**
 - State-of-the-art analysis & suitability
- **Resource management techniques**
 - State-of-the-art analysis & suitability



Main technical innovations



Achieved after 2 years:

- **Options and constraints for algorithm parallelisation**
 - Including 3D template matching
- **Designs of algorithm parallelisation**
 - Measurements of speed-up obtained
- **Design for virtualisation**
 - background and real-time processing on a single multi-core
 - workflow implementations with virtualisation & resource management



Achievements image processing



➤ Challenges

- Increase performance (throughput, latency and jitter)
- No increase in costs
- Achieve controllability and predictability

➤ Achievements

- Streaming performance management in 5 steps
 - Throughput – Latency – Jitter – Control – Predictability
- Philips Healthcare: latency and dose reduction:

system/SW	Algorithm	X-Ray Dose	max. fps		with IO at 30 fps	
			w/o IO	with IO	latency [ms]	Jitter [ms]
target	old & new	33-50%	-	66	40	16
SOTA core2	old	100%	-	36	45	10
SOTA Nehalem	old	100%	60	51	39	25 + hiccups
new on Nehalem	old	100%	114	108	15	3
new on Nehalem	new	20-50%	-	60	54	?

Achievements virtualisation



➤ Challenges

- The efficient mapping of multiple RT tasks onto a multi-core system is an unsolved case in the scientific literature
- Applications presenting high variability in required computing resources
- Non-RT (MS Windows) environment for user interaction

➤ Achievements

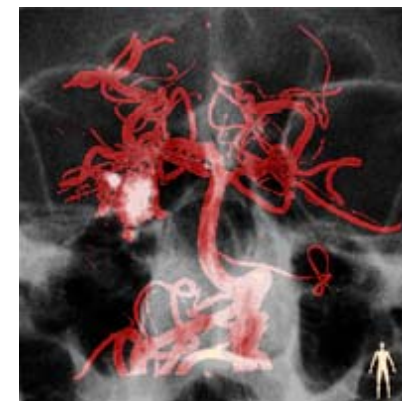
- Use 8 cores in 1 PC instead of 12 cores in 2 PCs
- Dimension the processing platform for average situations
 - Address applications with important variations in computing resource needs
- Meet RT constraints while hosting virtualized environments with satisfying responsiveness
 - Matter of # μ s jitter for RT part, matter of # ms for virtualized part

➤ Challenges

- Fill a technological gap between low scale and high scale distributed processing for neuro-imaging research
- Provide automated high-throughput system for the in-vitro medical diagnostics

➤ Achievements

- Bridged the gap by connecting multiple multi-core hardware platforms
- Made a step from manual to automated high-throughput image scanning systems



Conclusion

HiPiP: Affordable parallel high-tech image processing applications

- High throughput image processing
 - Very large and heterogeneous data sets
- Encouraging improvement results
- Demonstrators in development
- Important step towards reaching objectives

