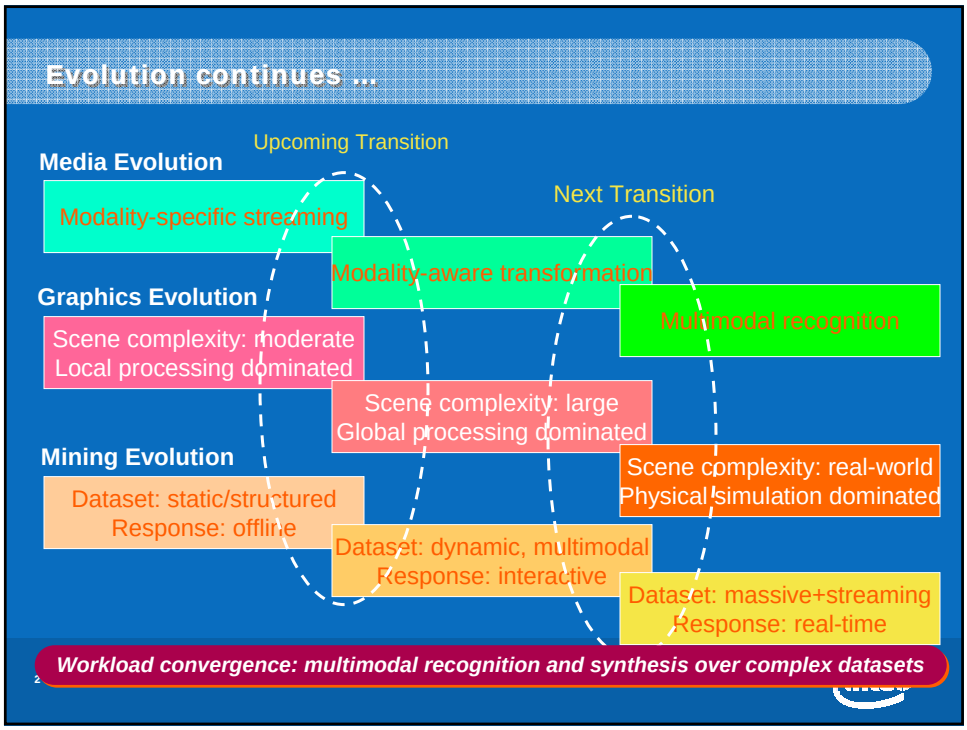
Teraflops for the Masses: Killer Apps of Tomorrow

Pradeep K. Dubey

Senior Principal Engineer
Corporate Technology Group

EDGE
UNC, Raleigh, May 23, 2006



Evolving towards model-based computing

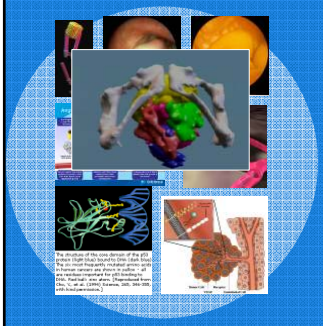
Large dataset mining
Semantic Web/Grid Mining
Streaming Data Mining
Mining
Distributed Data Mining
Content-based Retrieval
Indexing
Collaborative Filters
Multidimensional Indexing
Streaming
Dimensionality Reduction
Dynamic Ontologies
Efficient access to large, unstructured, sparse datasets
Stream Processing

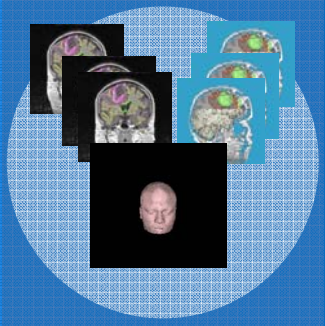
Multimodal event/object Recogn
Statistical Computing
Mach
Cluster
on
Recognition
Bayesian
Mod
Neural netwo
networks
LP/IP/QP/Sto
mization

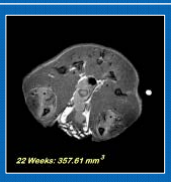
Photo-real Synthesis
Real-world animation
Synthesis
Ray tracing
Global Illumination
Behavioral Synthesis
Graphics
Physical simulation
Kinematics
Emotion synthesis
Audio synthesis
Video/Image synthesis
Document synthesis

intel

Recognition | Mining | Synthesis





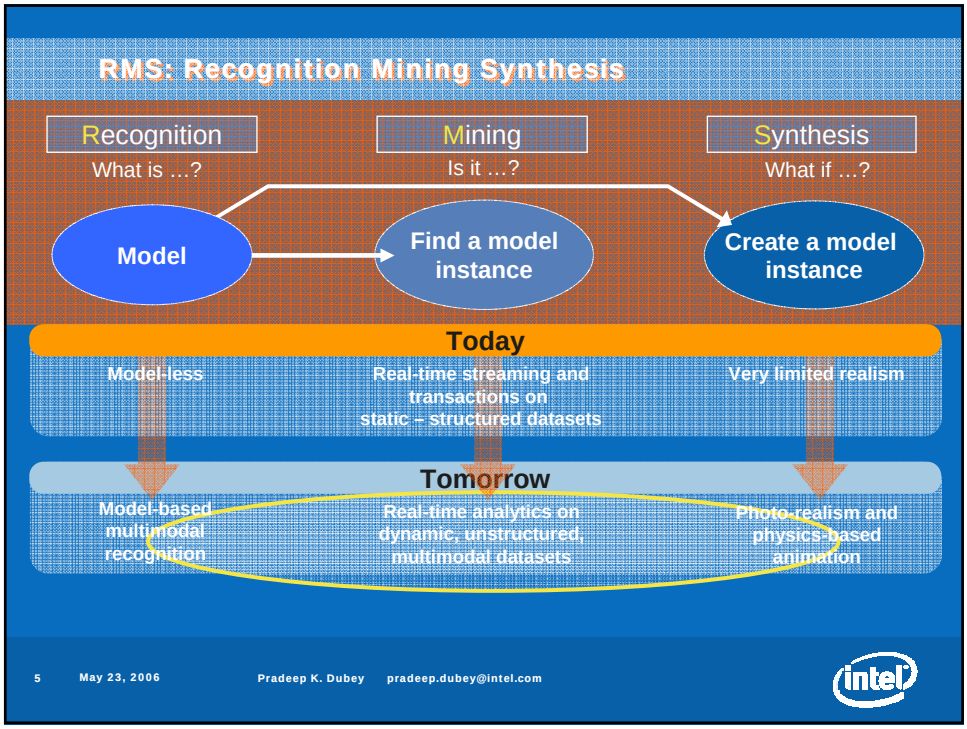


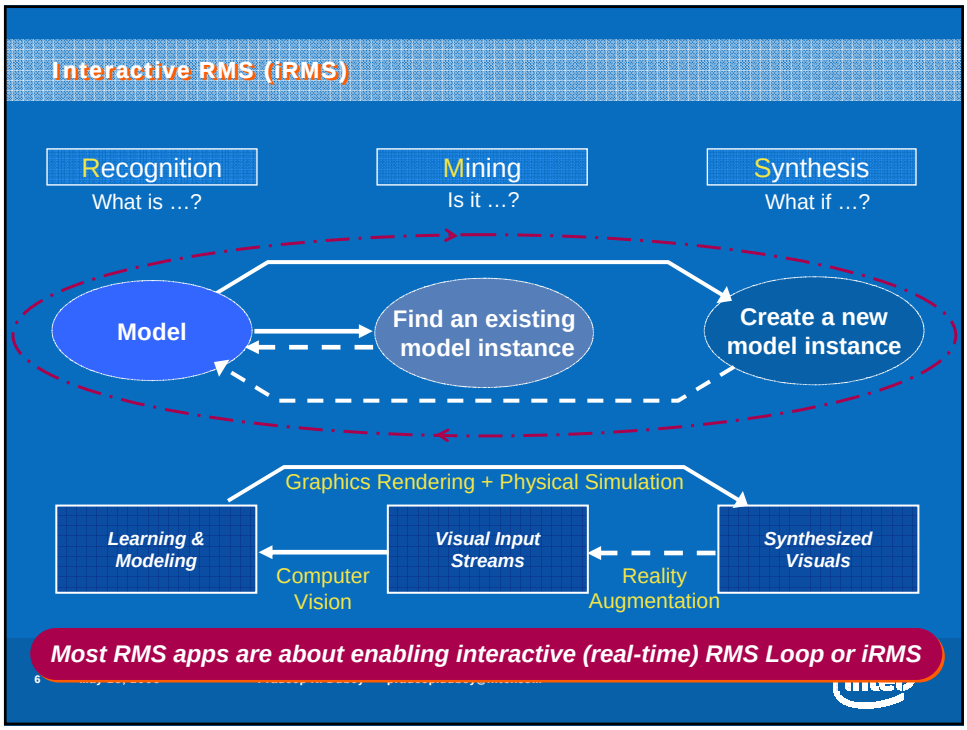
What is a tumor? | Is there a tumor here? | What if the tumor progresses?

It is all about dealing efficiently with complex multimodal datasets

Images courtesy: http://splweb.bwh.harvard.edu:8000/pages/images_movies.html

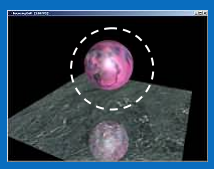
intel


RMS: Recognition Mining Synthesis
Recognition
What is …?
Mining
Is it …?
Synthesis
What if …?
Model
Find a model instance
Create a model instance
Today
Model-less
Real-time streaming and transactions on static – structured datasets
Very limited realism
Tomorrow
Model-based multimodal recognition
Real-time analytics on dynamic, unstructured, multimodal datasets
Photo-realism and physics-based animation
5 May 23, 2006 Pradeep K. Dubey pradeep.dubey@intel.com

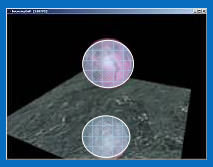

Interactive RMS (iRMS)
Recognition
What is …?
Mining
Is it …?
Synthesis
What if …?
Model
Find an existing model instance
Create a new model instance
Graphics Rendering + Physical Simulation
Learning & Modeling
Visual Input Streams
Synthesized Visuals
Computer Vision
Reality Augmentation
Most RMS apps are about enabling interactive (real-time) RMS Loop or iRMS

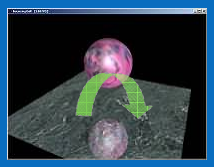
Next-Generation Entertainment

RMS Primitives:


Model the ball


Find the ball

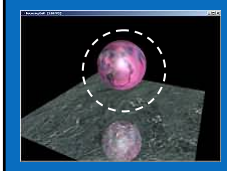

Replace the ball

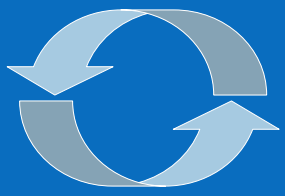

Shade/Bounce the ball

Going beyond media-stream encode-decode-transcode!

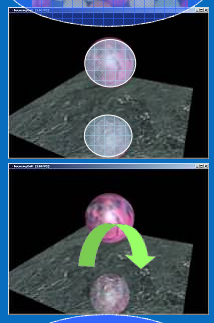
Real-time DCC Loop

What if … what if …


Model the ball


RMS Closed Loop
Rendering+Physics+Vision

Mine/Track/Replace the ball


Shade/Bounce the ball

Going beyond 'red-eye removal'

Where are we headed …

Rendering
Simulation

collision detection
force solver
global illumination
…

Machine learning
Neural networks
Probabilistic reasoning

Fuzzy logic
Belief networks
Evolutionary computing
Chaos theory
…

Physics
Dynamics

+

Soft Computing
Constraints

=

Soft Physics?
Constraint Dynamics

RMS Computing Core

Unstructured Information Management

Analytics

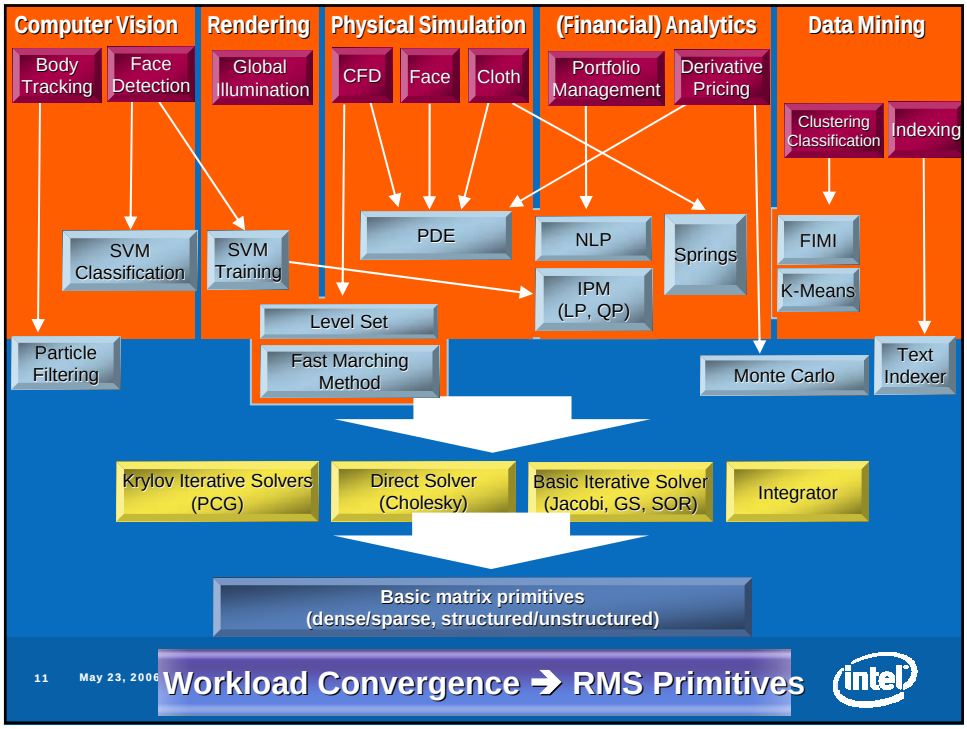
Vision/Tracking

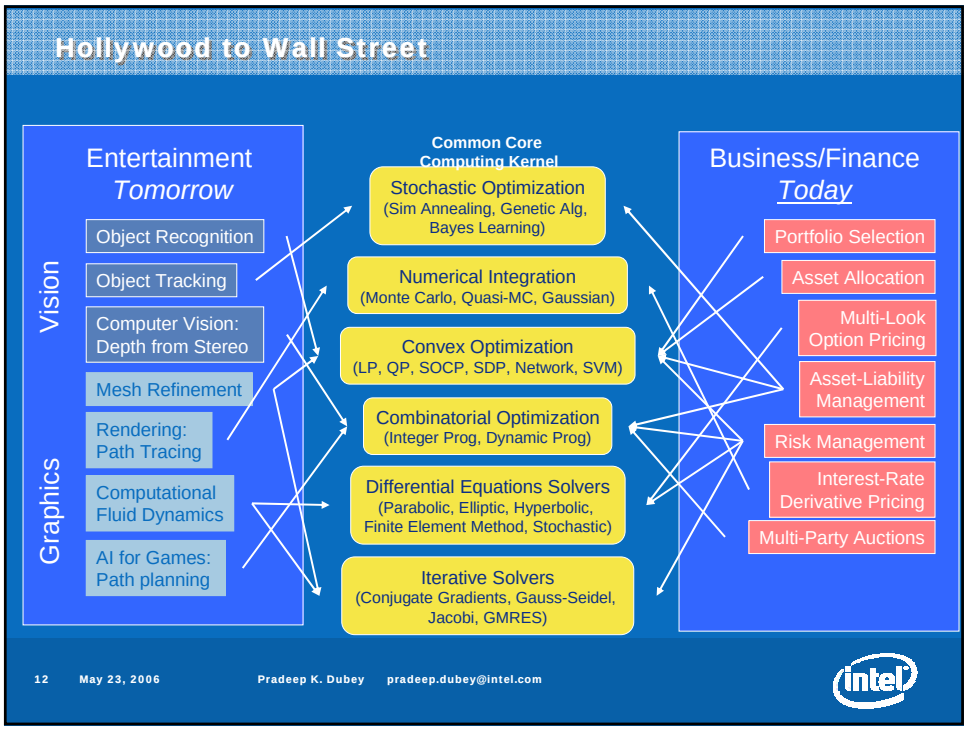
Gaming

Benefiting Applications
Real-time asset management, text mining
camera stream mining, 3D graphics …

Pool of Mathematical Techniques
Conic optimization, Subspace projection …

Pool of RMS Functions
Interior-point, Spectral Bundle, SVM …


Computer Vision
Rendering
Physical Simulation
(Financial) Analytics
Data Mining
Body Tracking
Face Detection
Global Illumination
CFD
Face
Cloth
Portfolio Management
Derivative Pricing
Clustering Classification
Indexing
SVM Classification
SVM Training
PDE
NLP
Springs
FIMI
IPM (LP, QP)
K-Means
Level Set
Particle Filtering
Fast Marching Method
Monte Carlo
Text Indexer
Krylov Iterative Solvers (PCG)
Direct Solver (Cholesky)
Basic Iterative Solver (Jacobi, GS, SOR)
Integrator
Basic matrix primitives (dense/sparse, structured/unstructured)
11
May 23, 2006
Workload Convergence → RMS Primitives
intel


Hollywood to Wall Street
Entertainment Tomorrow
Vision
Graphics
Object Recognition
Object Tracking
Computer Vision: Depth from Stereo
Mesh Refinement
Rendering: Path Tracing
Computational Fluid Dynamics
AI for Games: Path planning
Common Core Computing Kernel
Stochastic Optimization (Sim Annealing, Genetic Alg, Bayes Learning)
Numerical Integration (Monte Carlo, Quasi-MC, Gaussian)
Convex Optimization (LP, QP, SOCP, SDP, Network, SVM)
Combinatorial Optimization (Integer Prog, Dynamic Prog)
Differential Equations Solvers (Parabolic, Elliptic, Hyperbolic, Finite Element Method, Stochastic)
Iterative Solvers (Conjugate Gradients, Gauss-Seidel, Jacobi, GMRES)
Business/Finance Today
Portfolio Selection
Asset Allocation
Multi-Look Option Pricing
Asset-Liability Management
Risk Management
Interest-Rate Derivative Pricing
Multi-Party Auctions
12
May 23, 2006
Pradeep K. Dubey
pradeep.dubey@intel.com
intel

RMS Computing Core: Scaling to Next Generation Needs

Map-based shading	Global Illumination based
SIMPLEX based linear optimization	IPM based LP/QP/NLP optimization
Mass-Spring based deformation	FD/ FEA/FV based deformation
Marker-based explicit surface tracking	Level Set based implicit surface tracking
Linear manifold based recognition/modeling	Non-linear manifolds computer vision
Linear Complementarity problem	Non-linear Complementarity
Low dimension classifiers	High dimension classifiers

Non-Linear And Generative

Summary

There are *mass applications* that require significant increase in compute density

- There is nothing as general-purpose as physics!
- Visual computing is a proxy of this much larger class (RMS)

These applications are not linear extensions of existing usage

- Optimal platform for such apps should not be linear extension either

There is a significant performance difference between a *brute-force* CMP Vs. a *smart* CMP targeted for this class

- There is significant opportunity for silicon differentiation

These apps will likely be the driver for most future technology vectors

- Programming to processor to memory technology


intel
Leap ahead™
15 May 23, 2006 Pradeep K. Dubey pradeep.dubey@intel.com
intel