The HelpMeSee Project

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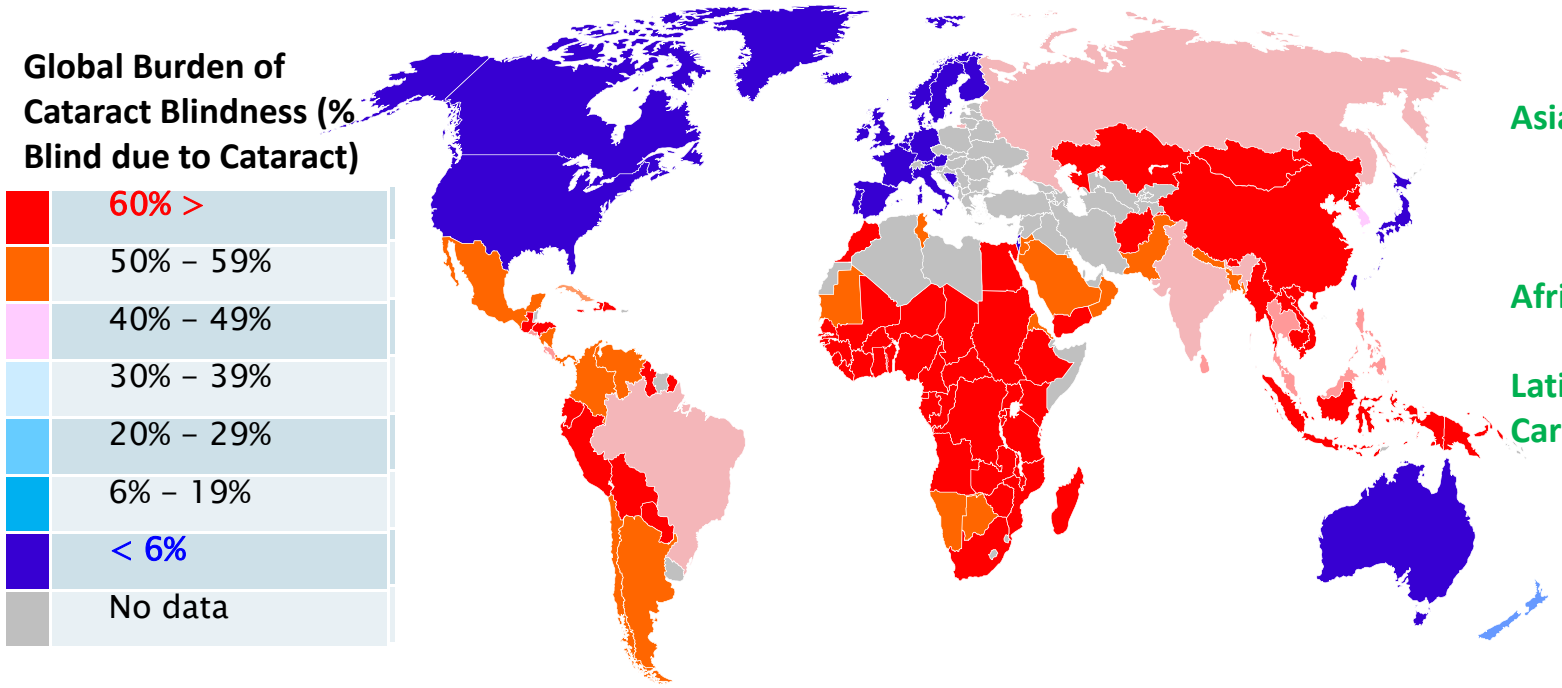
THE PROBLEM...



Asia – 16 Million
China – 7 Million
India – 5 million

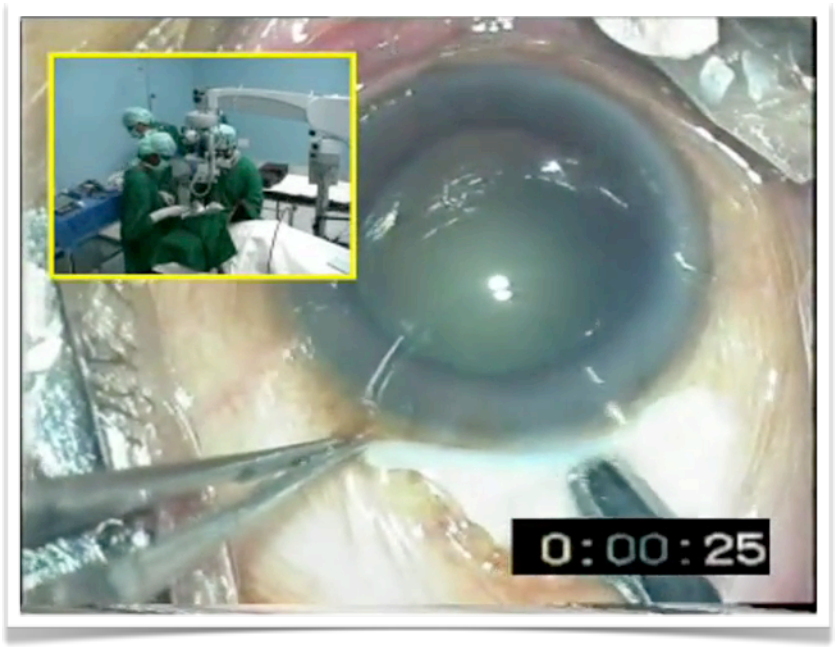
Africa – 2.5 Million

Latin America & the Caribbean – 1.8 million

20 million children and adults are blind today due to cataract

… AND A POSSIBLE SOLUTION

- Introduce a new technique called MSICS which costs $50 per surgery
  - Whereas phacoemulsification (current surgical technique) costs about $5,000
  - A cost which is beyond the reach of 95% of the blind persons
  - A MISCS procedure can be done in 5 to 15 minutes per eye



www.helpmesee.org

THE “HELP ME SEE” PROJECT IN A NUTSHELL

Significant global need

- Estimated 20 million needlessly blind due to cataract, to double in the next decade, if no action is taken.
- 167 million estimated to be progressively blind due to cataract and.
- Poor quality of cataract surgical care and high cost.

Unique solution model

- MSICS – A proven, sutureless, 5 – 10 minutes , high quality and cost effective procedure.
- Lessons from Aviation Training – Training Cataract Surgeons through simulation based instructional design and courseware.
- Train over 30,000 highly skilled cataract specialists in Asia, Africa and Latin America.
- Support 8,000 -10,000 surgical practice units to deliver 60 million high quality and affordably priced MSIC surgeries at $35 - $50 per surgery.

HELP ME SEE:
A UNIQUE OPPORTUNITY FOR SIMULATION-BASED TRAINING

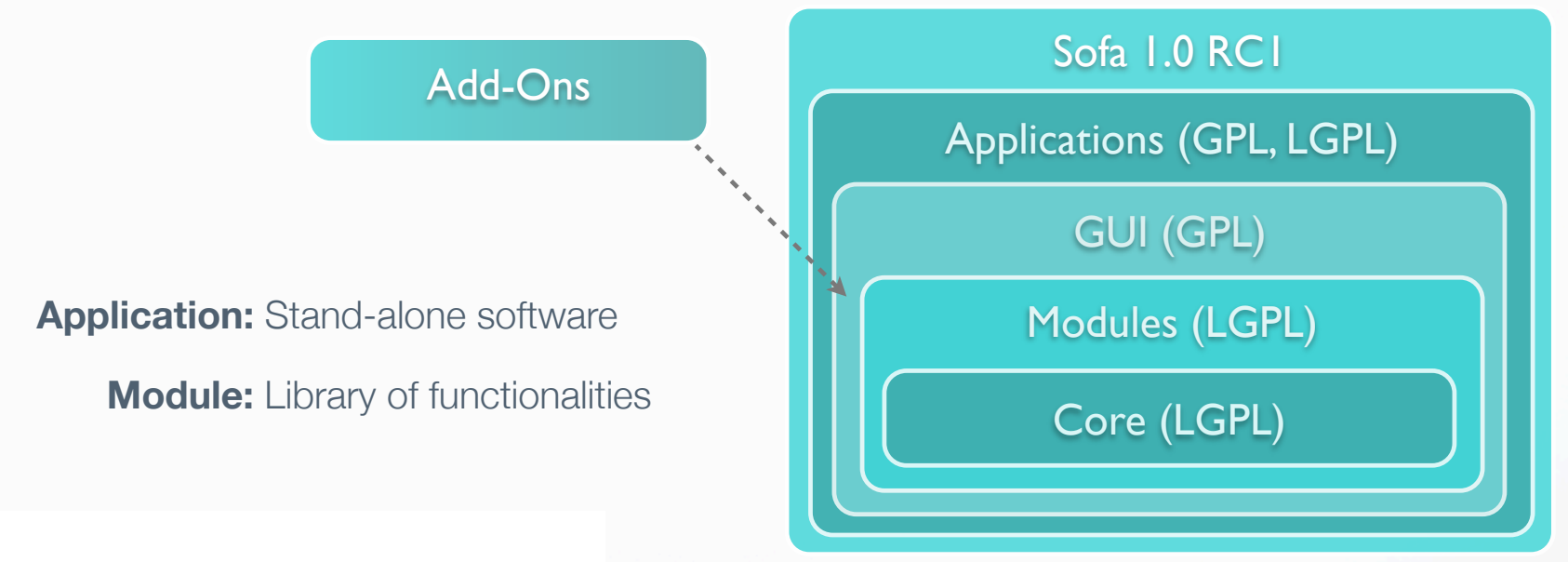
- Training requirements are very high
  - Learn how to handle multiple complications
  - Deal with a large number of anatomical variations
  - 200 to 300 training sessions on simulation
  - Followed by 20 actual surgeries under supervision

90% of the training done using computer-based courseware and simulation

- Requirements from a technical standpoint are very high
  - Actually, probably the highest of any computer-based training system
  - Physics-based realism (tissue deformation, physiology, …)
  - 250 anatomical variations

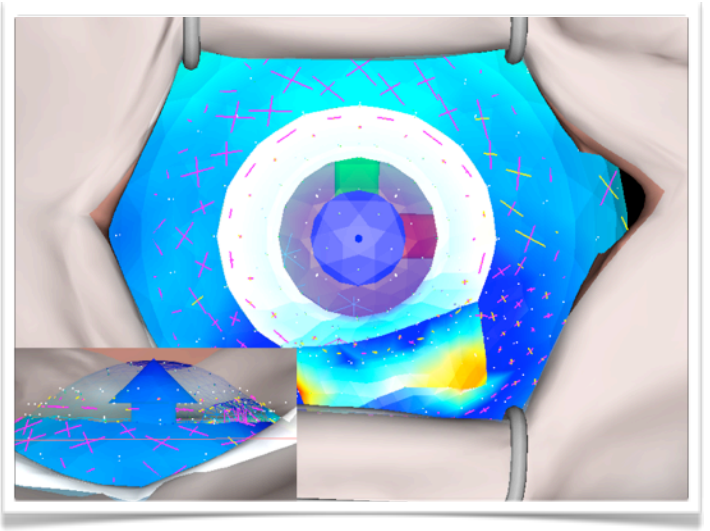
SIMULATION: LEVERAGING RESEARCH RESULTS

- Advanced physics-based simulation based on SOFA
  - Several existing components (e.g. collision detection) were re-used
  - Many new, derived components, were developed



SIMULATION: LEVERAGING RESEARCH RESULTS

- Advanced physics-based simulation based on SOFA
  - Several existing components (e.g. collision detection) were re-used
- Physics-based modeling of the cornea, conjunctiva and sclera
  - Each layer can move independently, and resists to intraocular pressure
  - Very efficient non-linear finite element technique
- Model of intraocular pressure
  - The pressure drops if an opening is created
  - The pressure controls the eye ball “stiffness”
- Instrument interaction
  - Non-smooth contact problems
  - Cutting (i.e. Real-time topological changes)
  - Haptic rendering including friction



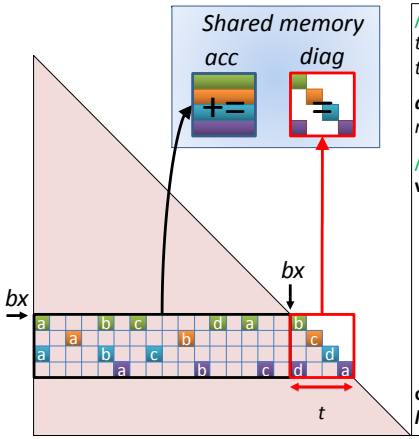
SIMULATION: LEVERAGING RESEARCH RESULTS

- Advanced physics-based simulation based on SOFA
  - Several existing components (e.g. collision detection) were re-used
- Real-time computation using advanced solvers

$$\mathbb{M}(\mathbf{q})\ddot{\mathbf{q}} = \mathbb{P}(t) - \mathbb{F}\left(\mathbf{q}, \dot{\mathbf{q}}\right) + \mathbb{H}(\mathbf{q})^T \boldsymbol{\lambda}$$

$$\underbrace{\left(\mathbf{M} + h\mathbf{B} + h^2\mathbf{K}\right)}_{\mathbf{A}} \underbrace{d\dot{\mathbf{q}}}_{\mathbf{x}} = \underbrace{-h^2\mathbf{K}\dot{\mathbf{q}}_i - h\left(\boldsymbol{f}_i + \boldsymbol{p}_f\right)}_{\mathbf{b}} + h\,\mathbb{H}(\mathbf{q})^T\boldsymbol{\lambda}_f$$

CPU Solver
+
Asynchronous GPU Preconditionner
=
Real-time computation of complex deformations with contacts




```
// coordinates of the threads
tx = threadId.col  // correspond to the letters a,b,c,d
ty = threadId.row  // correspond to the colors

acc[ty][tx] = 0;   diag[ty][tx] = 0
row_begin = rowind[bx + ty]; row_end = rowind[bx + ty + 1]

// get the contributions of t lines in shared memory
while (row_begin < row_end) do
   col = colptr[row_begin + tx] // read in global memory

   if (col < bx) then // accumulate the contributions
      acc[ty][tx] -= value[row_begin + tx]*sol[bx+ty]
   else  // copy the bloc diagonal
      diag[ty][tx] = value[row_begin + tx]
   fi
   row_begin += t // next value on the line
od
local_synchronization // wait all the threads
```

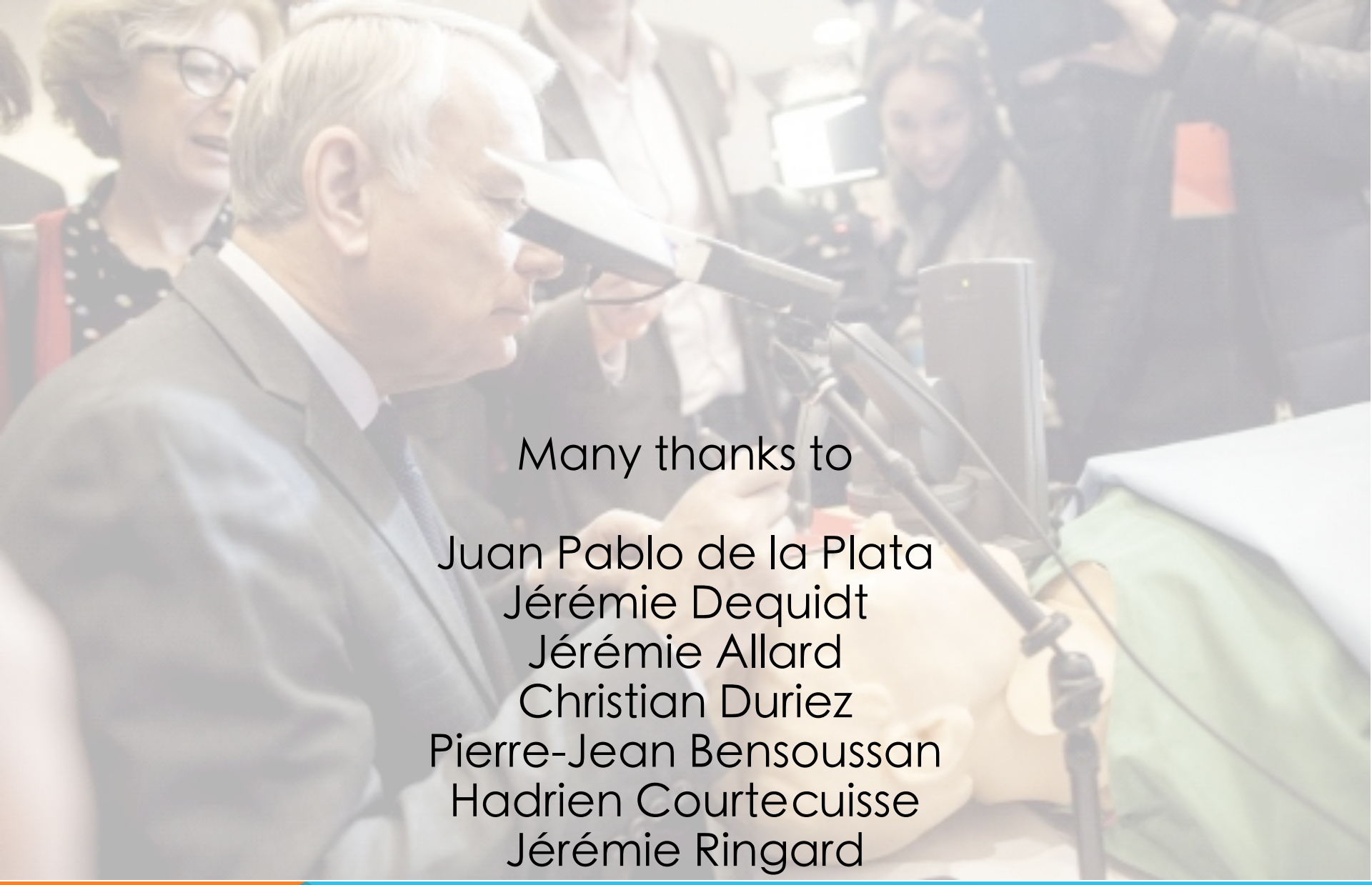
MSICS SIMULATION: FIRST RESULTS

MANY CHALLENGES…

- From research to products
  - It's a very long path
  - How do we create value along the way?
- In general
  - Development vs. Research
  - Code vs. Publications
- It gets worse in the medical field
  - Added constraints from clinicians
  - Difficulty of working in a multi-disciplanary environment

… BUT REALLY WORTH THE TROUBLE

- If you succeed
  - The outcome can be amazing !
  - Not only from a social stand point
  - But also it helps validate our research
  - And publications can have a broader impact



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