ADAMS

Virtual Prototyping

Design Optimization Technique for Mechanical System

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Mechanical Dynamics

Optimization Technology

- **Optimization of complex phenomenon**

  Concept of Multidisciplinary Optimization

- **Development of New Methodology**

  Genetic Algorithms

  Response Surface Methodology

  e.g. Crash Optimization by RSM

Background

Optimization for Structural Design

- Objective Function: Structural Weight
- Component, Stiffness, Crash

Optimization for Fluid Dynamics Design

- Objective Function: Lift, Drag
- Wing Section Design, Blade Design

Background

Optimization for Mechanical System Design

Few Achievement

- **Many design parameters**
- **Strong nonlinearity**
- **Difficult to define objective function**

In order to clarify the benefit of design optimization technique,

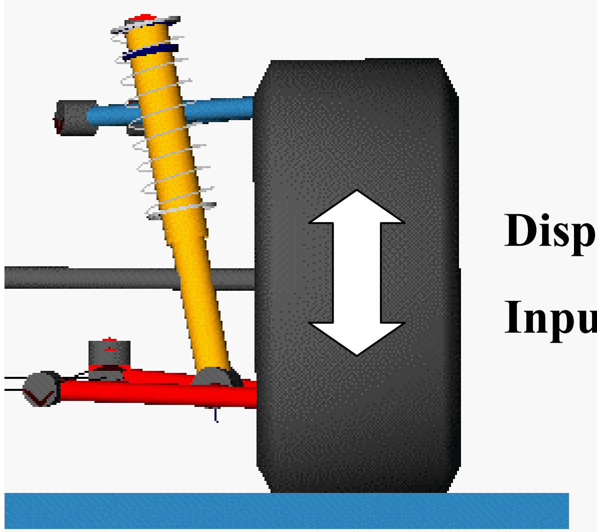
we conducted case study of suspension design.

Suspension Design

<Analysis 1>

Vertical Motion ±100mm

Evaluate Toe Characteristic



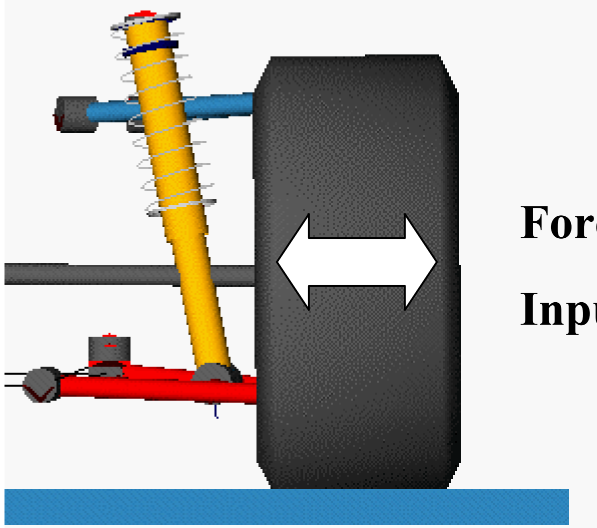
Displacement

Input ±100mm

<Analysis 2>

Static lateral Force ±2,000N

Evaluate Lateral Stiffness



Force

Input ±2000N

Suspension Design

20 Design Variables

Geometry: 18 Variables

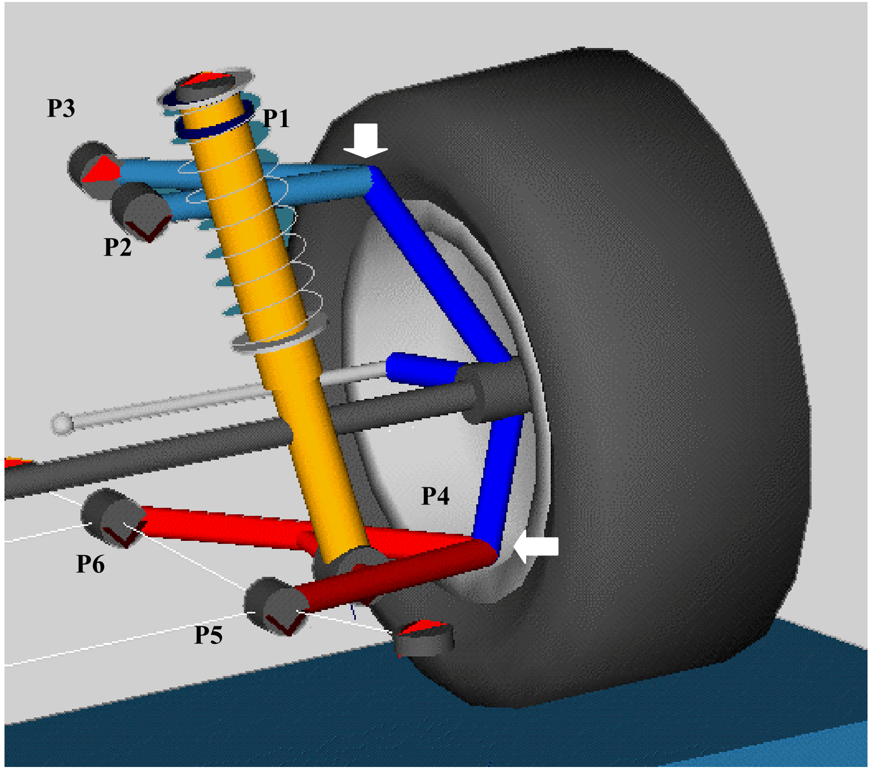
P1(x,y,z)-P6(x,y,z)

Original ±100mm

Bush : 2 variables

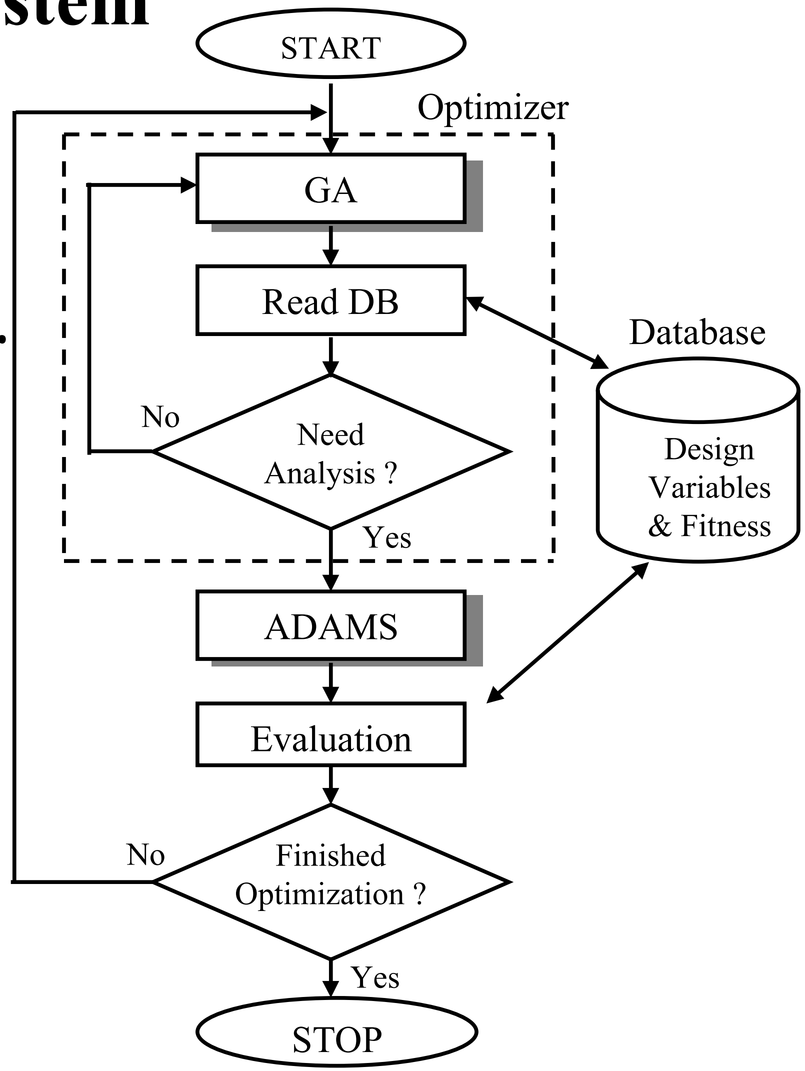
Bush_upr/Bush_lwr

40%-200% of original

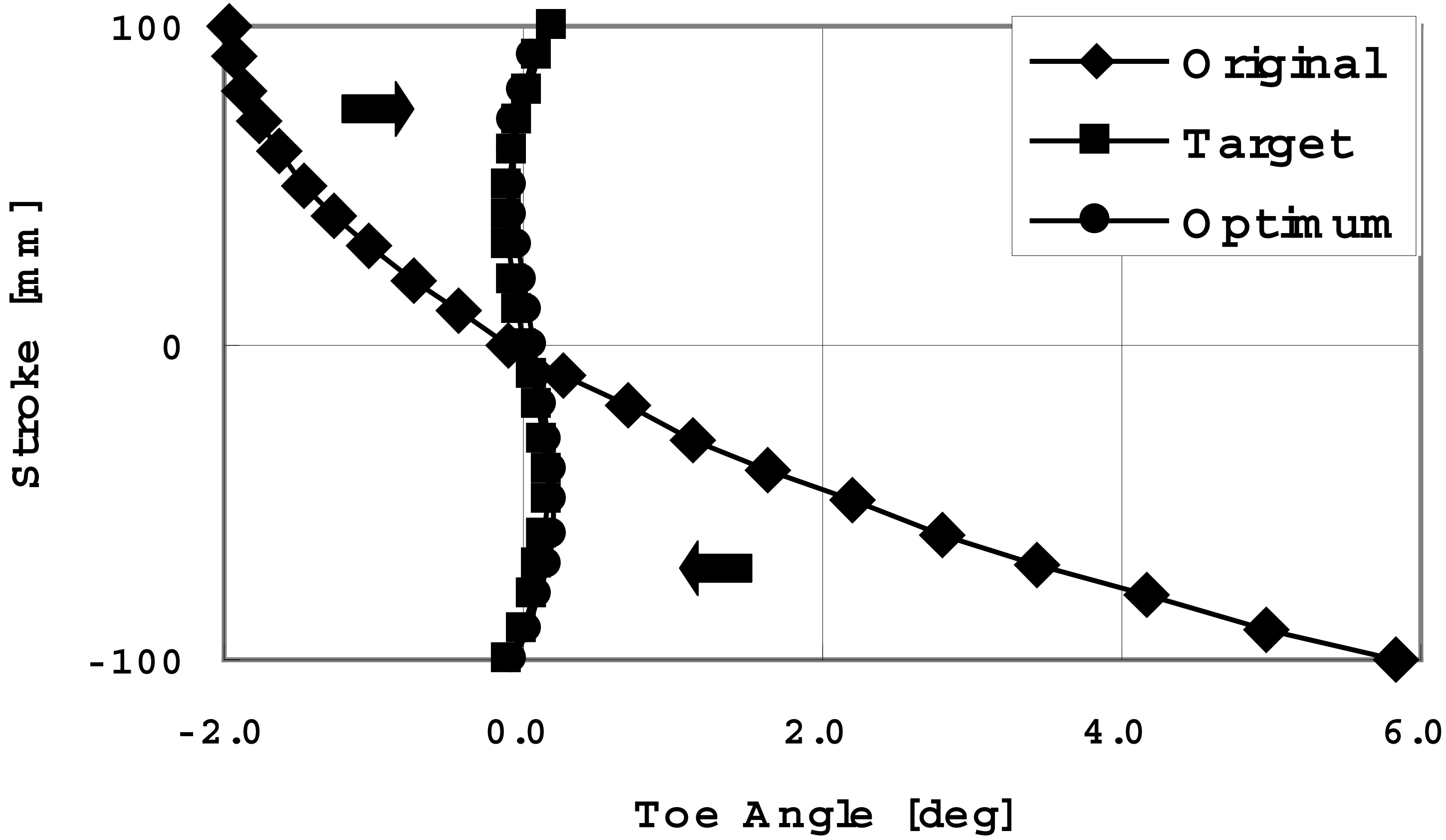


Developed Optimization System

- **Optimization Algorithm**
  - **By Genetic Algorithms (GA)**
- **Interface with ADAMS/Solver**
  - **Generate ADAMS Solver file using GA information**
  - **Evaluate the request data file and save data into database**
- **Skip the ADAMS simulation if conducted previously**



- *Optimized Toe Angle*
- *Target Toe : From Prof. Abe's Data*



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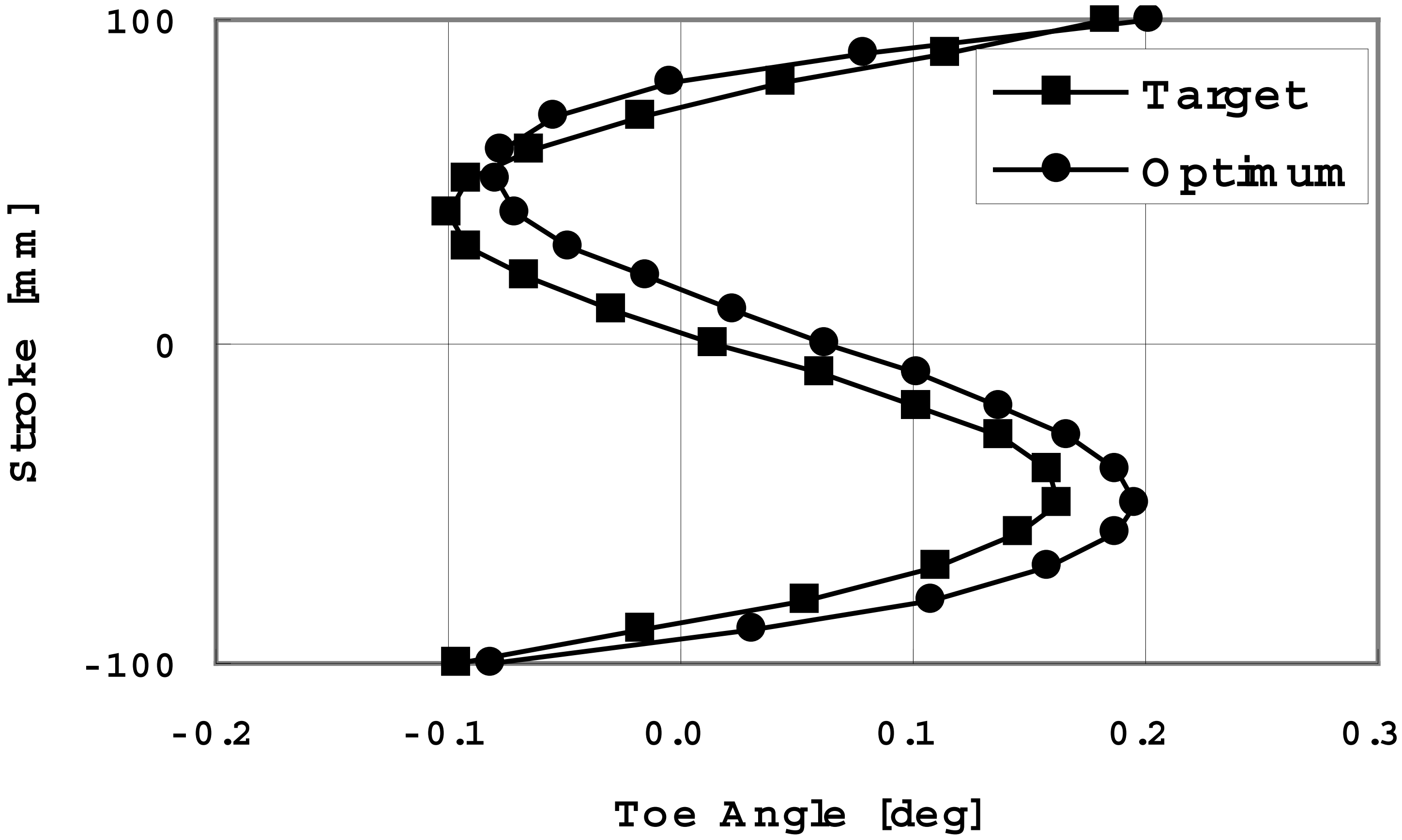
Case Study

- *Optimized Toe Angle*
- *Target Toe : From Prof. Abe's Data*



Maximum Error=0.05 deg after 3000 analyses

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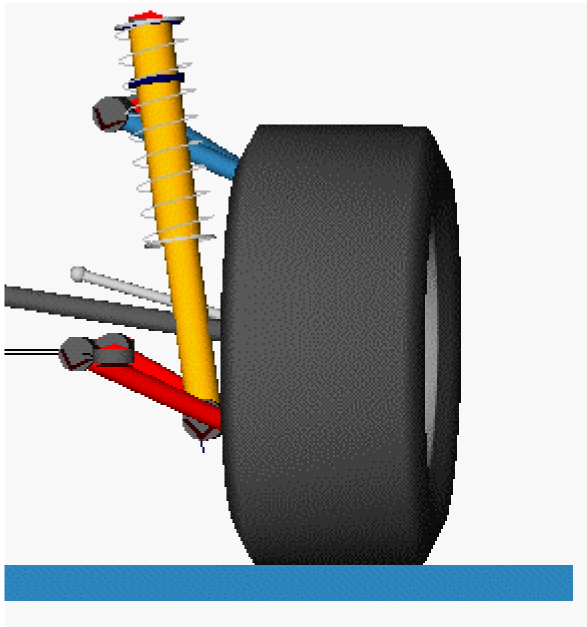
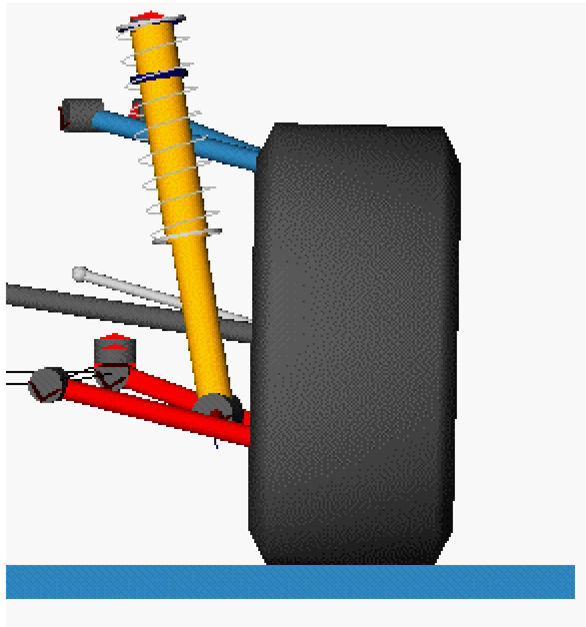
Case Study

■ *Optimized Toe Angle*



Original Model



Optimized Model

Comparison Toe Angle at Vertical Displacement -100mm

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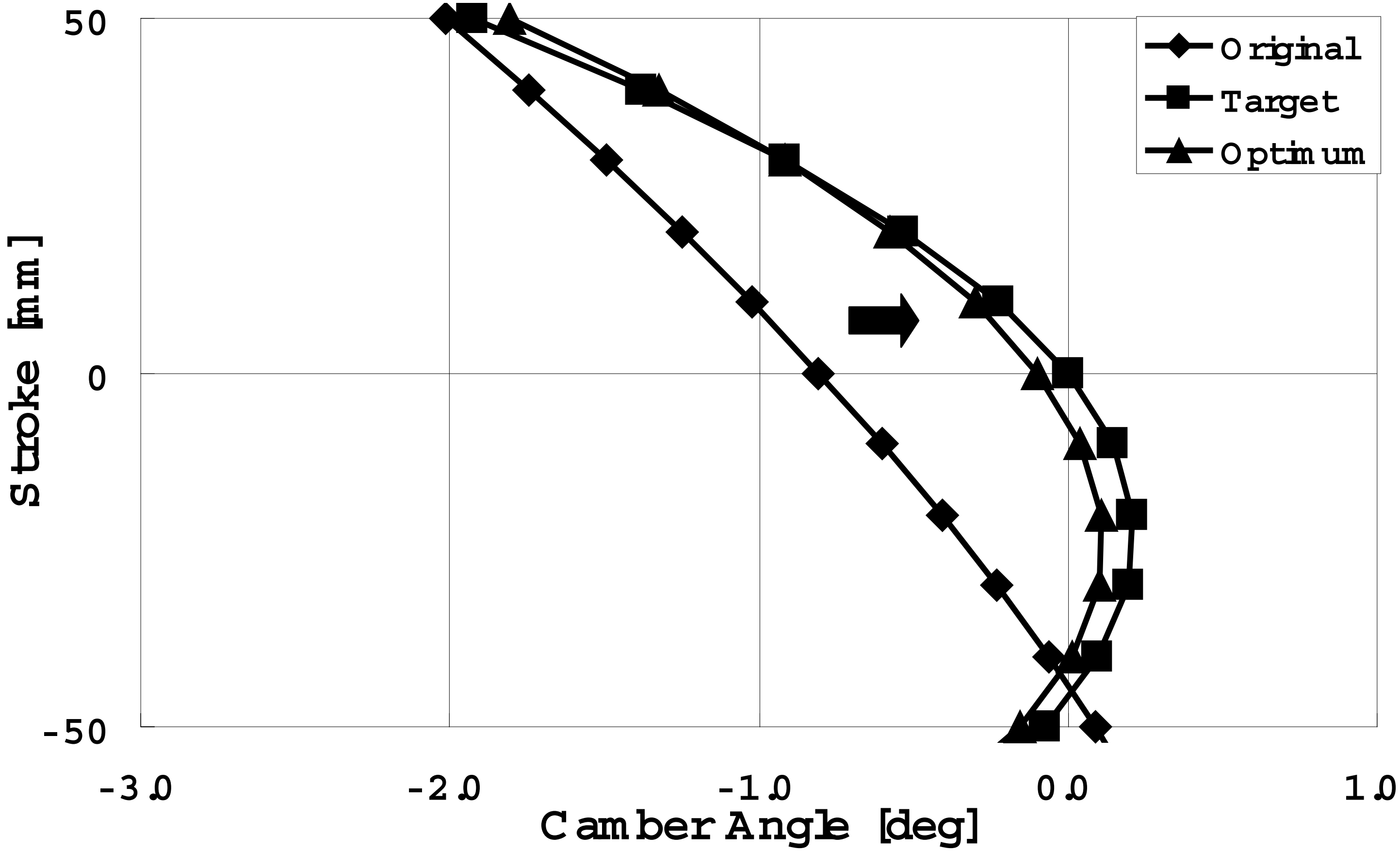
Case Study

- Optimized Camber Angle
- Target Camber : From Prof. Abe's Data



Maximum Error=0.05 deg after 3000 analyses

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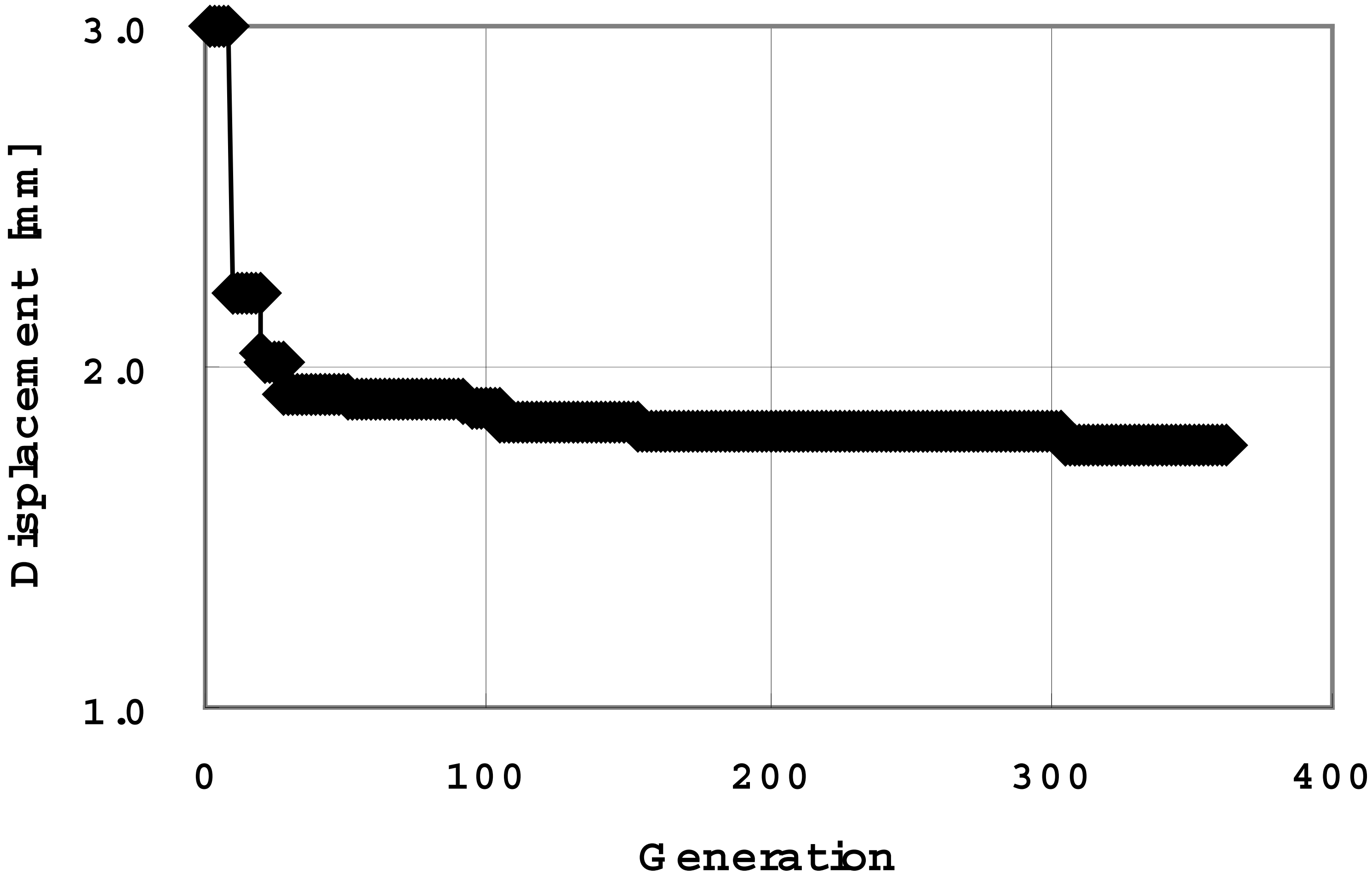
Case Study

- *Minimized Lateral Displacement*



Constraint: Toe Error less than 0.1 deg
Objective Function: Maximize Lateral Stiffness

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Conclusion

1)We have developed optimization system based on Genetic Algorithms for Mechanical System Design.

2)Using this system, we have optimized suspension system. Through the case study, the validity of the system was clarified.

3) We will apply optimization technique for complex systems.

4)Design optimization technique will supply outstanding contribution for the mechanical system engineering.

Comparison of Gradient Search with Genetic Algorithms for Nose Landing Gear

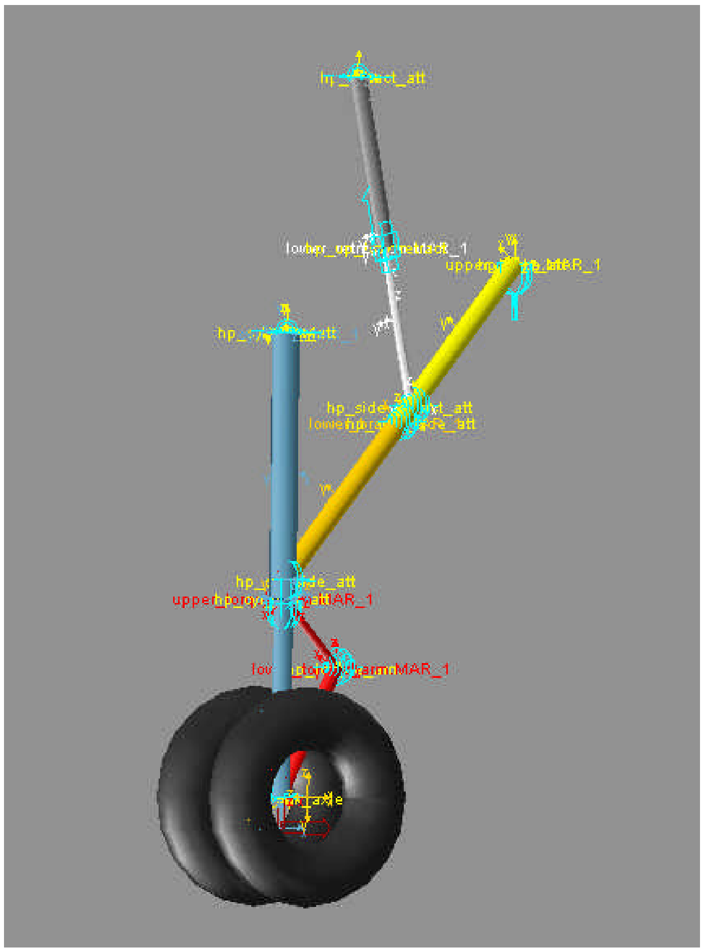
Patrick McNally, MDI

Ever wonder…?!?

Which is Best for Landing Gear Optimization : Genetic Algorithms or Gradient Search?

- Optimize geometric layout
- Maximize retraction efficiency
  - used in actuator sizing
  - ensures constant demand on hydraulic system during actuation
- Optimization constraints to ensure full retraction and avoid lockup conditions

Nose Landing Gear for Optimization



- Conventional aft-deploying (forward retracting) nose gear with collapsing brace
- Rigid Model only
- Design Variables:
  - 20 geometric layout variables
  - P1(x,y) -> P10(x,y)

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Retraction Efficiency Function

$$\left|\max\left(F_R\right)\cdot z_{\max}\right| - \int_{z_0}^{z_{\max}} F_R\left(z\right)\cdot dz$$

Where

F_R ~ retraction force

z ~ retraction position

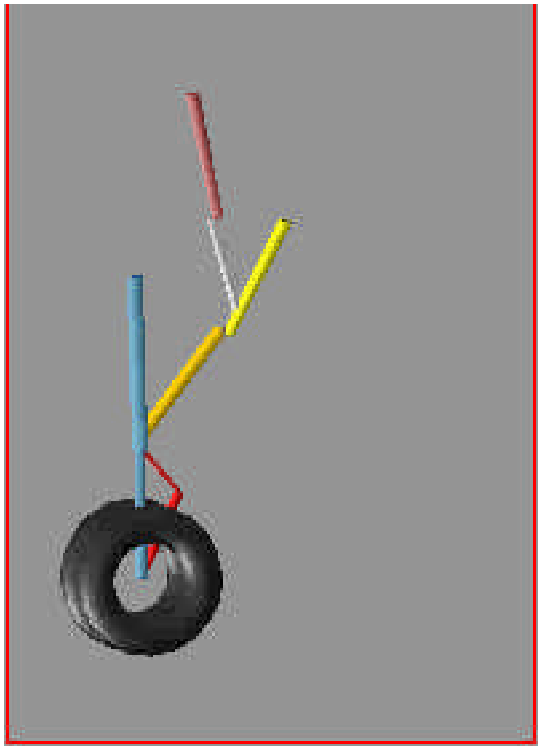
Rewritten as time function:

$$\left|\max\left(F_R\right)\cdot z_{\max}\right| - \int_{t_0}^{t_{\max}} F_R\left(z\right)\cdot \dot{z}\cdot dt$$

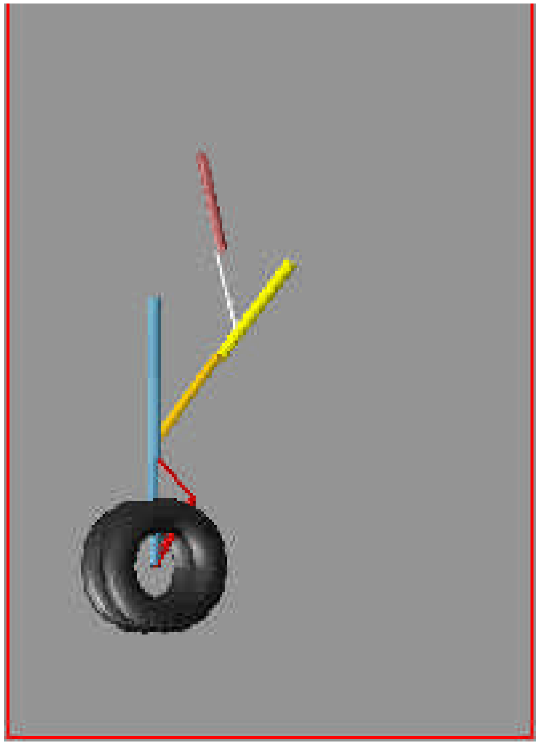
Solver and View language:

- View fun = (MAX{(Last_Run.MOT1.FZ.values)} * (MAX{Last_Run.DZ.values}) - LAST(.nosegear.DIFF_1))
- DIFF_1=MOTION(.nosegear.MOT1, 0, 1, 0) *VZ(.nosegear.lower_retraction.MAR507, .nosegear.upper_retraction.MAR407)

Initial Results Show Different Optimums Found through Different Searches

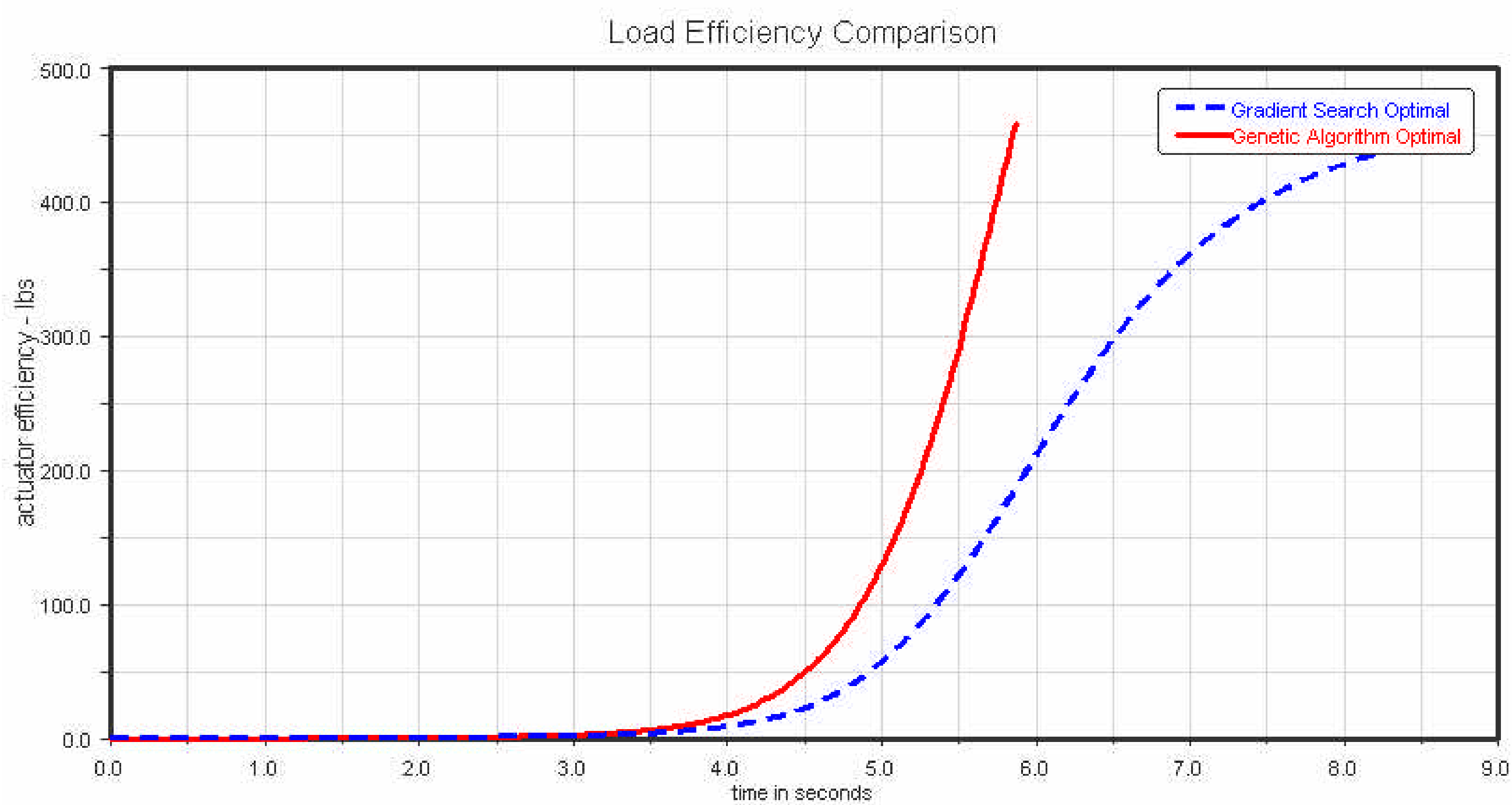


Gradient Search Optimization



Genetic Algorithm Optimization

Initial Results Show Genetic Algorithm Found Better Optimal



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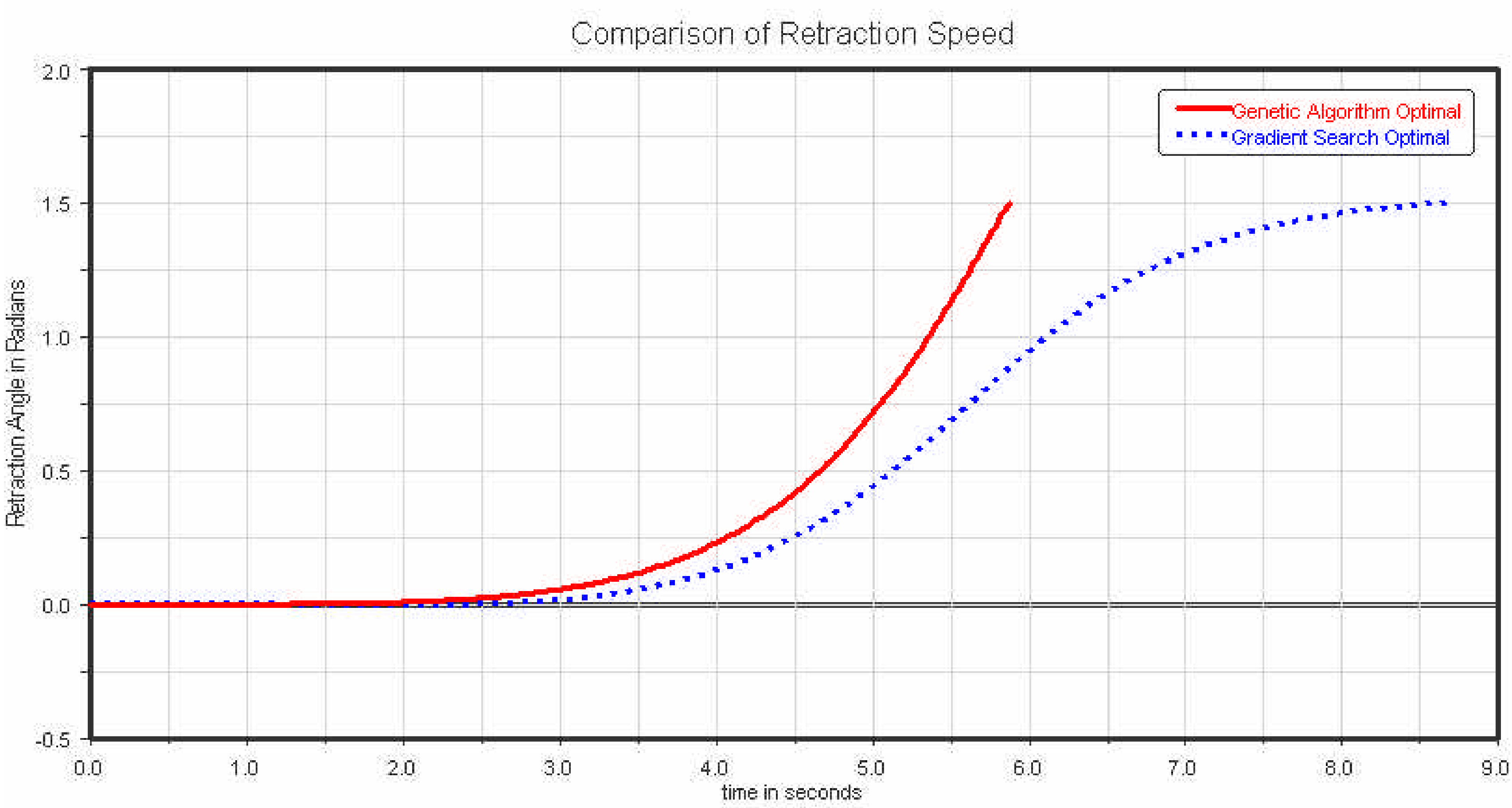
Initial Results Show Genetic Algorithm Found "Faster" Mechanism



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Conclusions for Landing Gear Problem

- ADAMS architecture allows easy comparison between design study and optimization methods
- Gradient search found local optimal, global optimal not known but *genetic algorithm found better solution*
- Hydraulic system effects being added to understand effect on optimal
- Main gear (nonplanar) mechanism being explored for effects of more complex layouts