# RYAN: Rendering Your Animation Nonlinearly projected

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Dynamic Graphics Project
Computer Science University of Toronto
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# Ryan Larkin

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# Psychorealism and *Ryan*

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# Projection

# Nonlinear Projection

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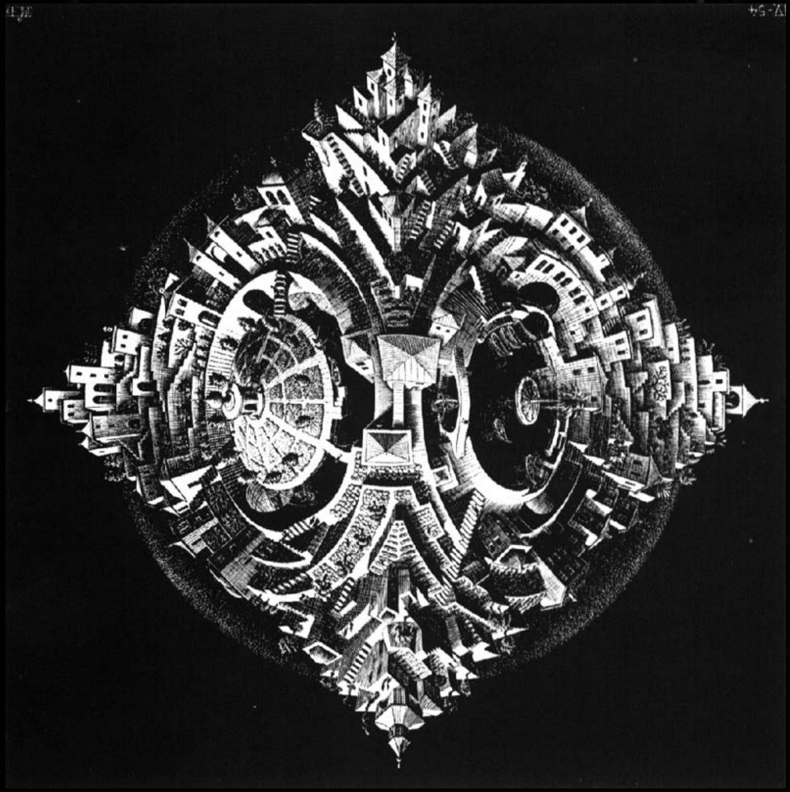
# Linear Perspective

- Good approximation of human visual system
- Conceptually simple and predictable
- Aids depth perception
- Efficient graphics pipelines

# Motivation

*Femme nue accroupie*
**Pablo Picasso**



*Tetrahedral Planetoid*
**M. C. Escher**

# Motivation


*Pearblossom Hwy. No. 2*
**David Hockney**

*Still Life with Fruit Basket*
**Cezanne**

# Nonlinear Perspective

- Extend visual range
- Avoid disjoint images for complex scenes
- Artistic expression

# The Problem…

Allow artists to explore, understand, and subsequently express complex 3D scenes

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**Linear Perspective**

Allow artists to explore, understand, and subsequently express complex 3D scenes

**Nonlinear Projection**

# Nonlinear Projection Goals

- Interactive and incremental
- Use of common animated camera
- Local linear perspective
- Continuous nonlinear projections
- Artistic control of composition, projection
- Coherent shading, shadows, lighting
- Handle complex scenes

# Related Work

- Image Processing (Max 83, Zorin & Barr 95, Seitz & Dyer 96, Collomosse & Hall 03)
- View-Dependent Deformation (Rademacher 99, Martín 00)
- Multi-Perspective Panoramas (Wood et al. 97, Rademacher & Bishop 98, Peleg et al. 00, Seitz & Kim 02)
- Nonlinear Ray Tracing (Wyvill & McNaughton 90, Glassner 00, Weiskopf 04)
- Multiprojection Rendering (Agrawala et al. 00, Glassner 04, Yu 04)
- Nonlinear Projection (Singh 02)

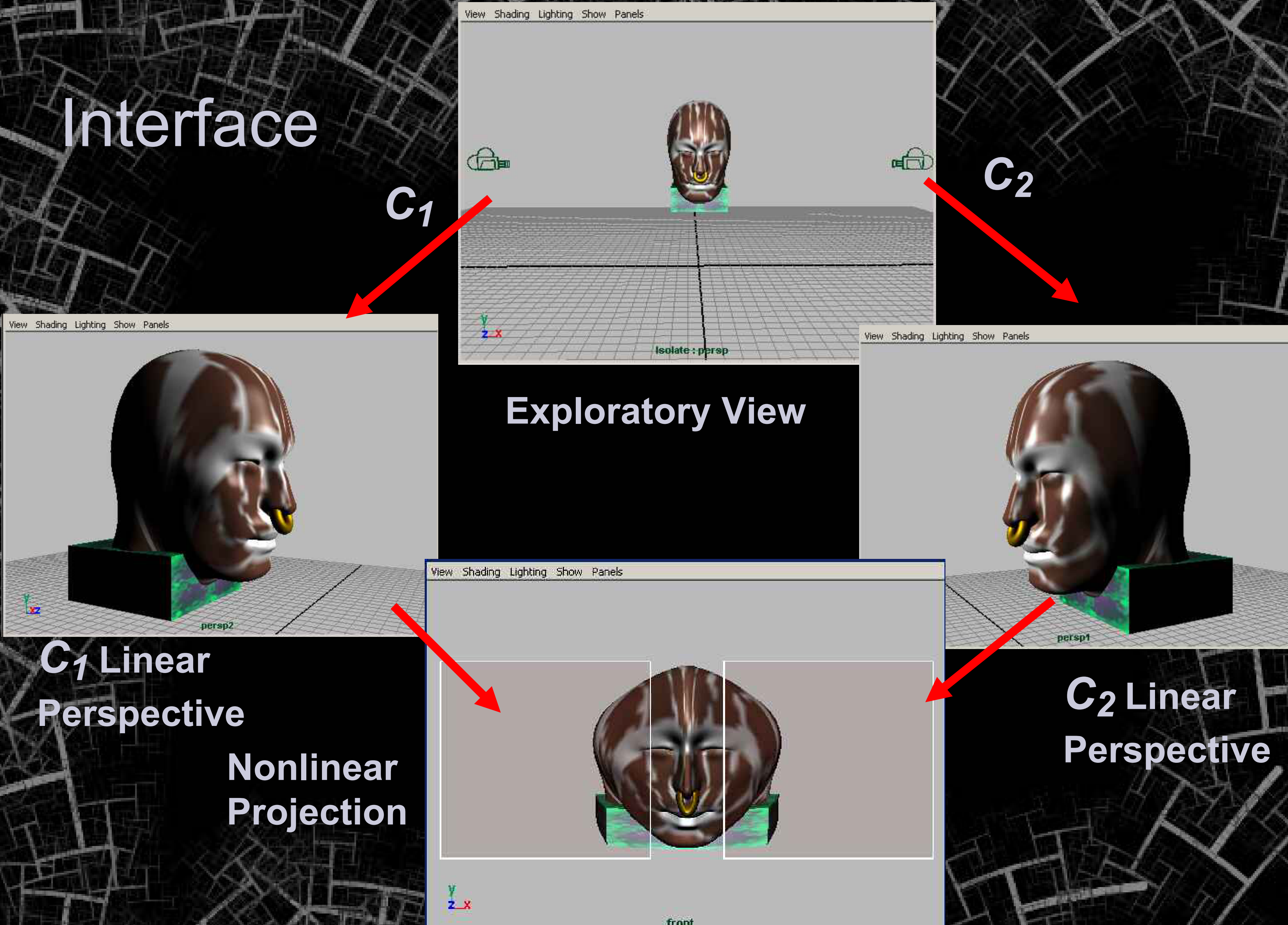
# Our Approach

- Combine linear perspective views (Singh 02)
- Extend weight computation from Singh 02
- New deformation approach for complex scenes and animated camera
- New constraint formulation with local control
- Shading from multiple points of view

# Workflow

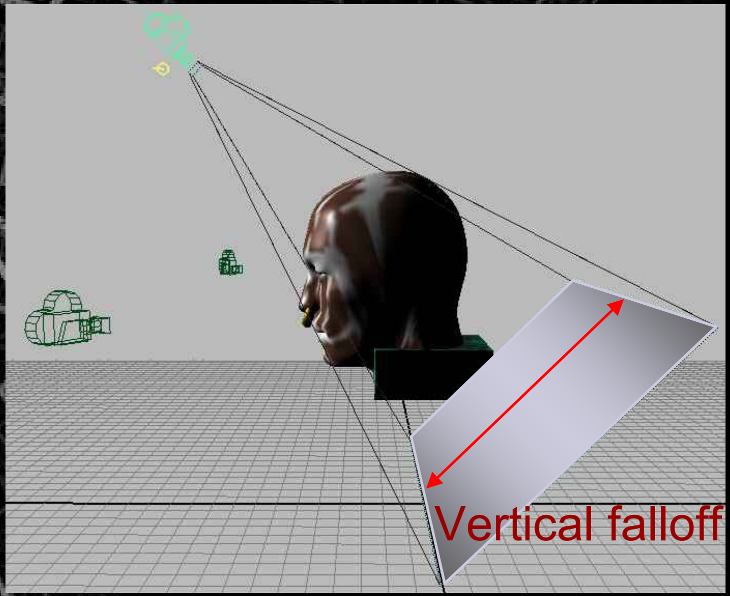
- Animate the *boss* camera as a normal CG camera
- Incrementally add *lackey* cameras to locally manipulate perspective
- Edit lackey weight functions
- Add constraints and edit viewport transformations

# Interface

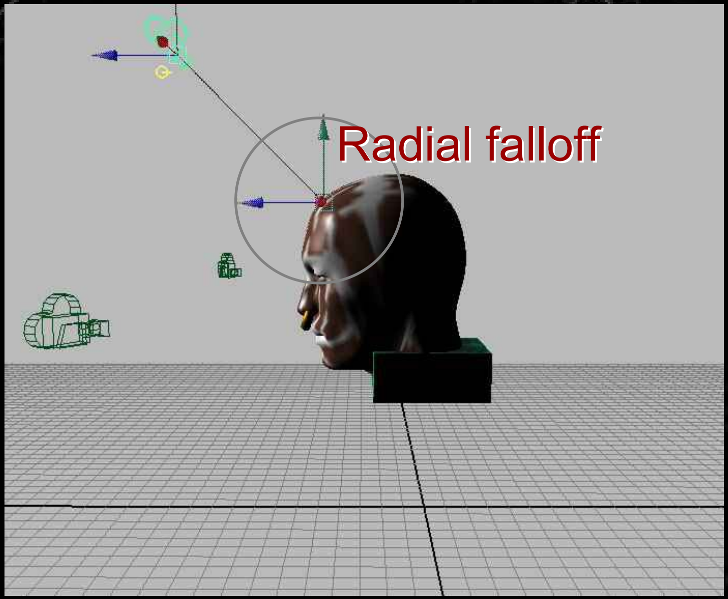


$C_1$
$C_2$
Exploratory View
$C_1$ Linear Perspective
$C_2$ Linear Perspective
Nonlinear Projection

# Defining projection weights

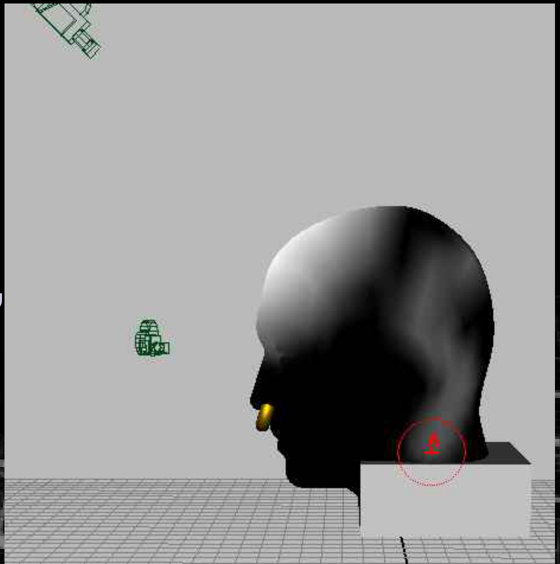



Directional

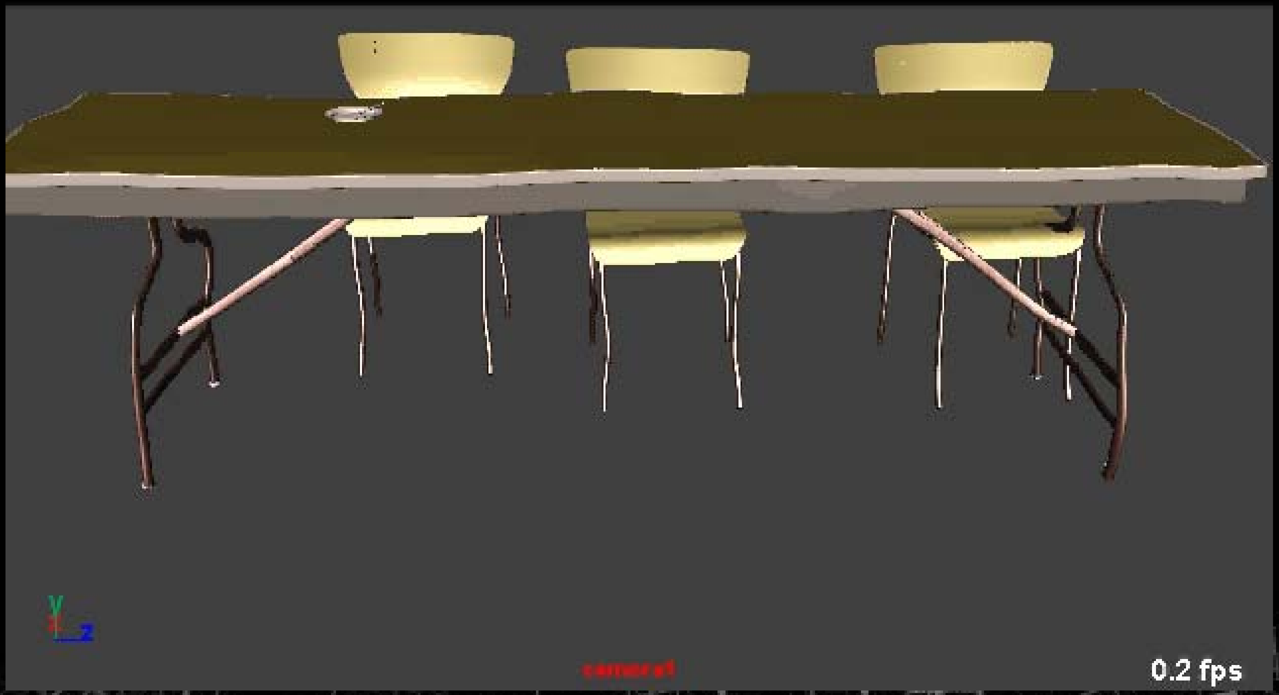



Positional

Feature based,
User Painted



# Example



# Nonlinear Projection Model

- *C,M,* and *V* are the eye-space, perspective, and viewport matrices for a linear perspective camera.
- A point in the scene *P* linearly projects to <*x,y*> in the image at depth *z* where, <*x,y,z*>=*PCMV.*

# Boss and lackey cameras

*Lackey* cameras induce projection deformations to scene geometry as seen by the *boss* camera

# Deformation from a lackey camera

For *P'* to appear in boss camera *b,* as *P* appears in lackey camera *i :*

$$P' = PC_iM_iV_i(C_bM_bV_b)^{-1}.$$

$$A_i = C_iM_iV_i(C_bM_bV_b)^{-1}$$

# Combining cameras

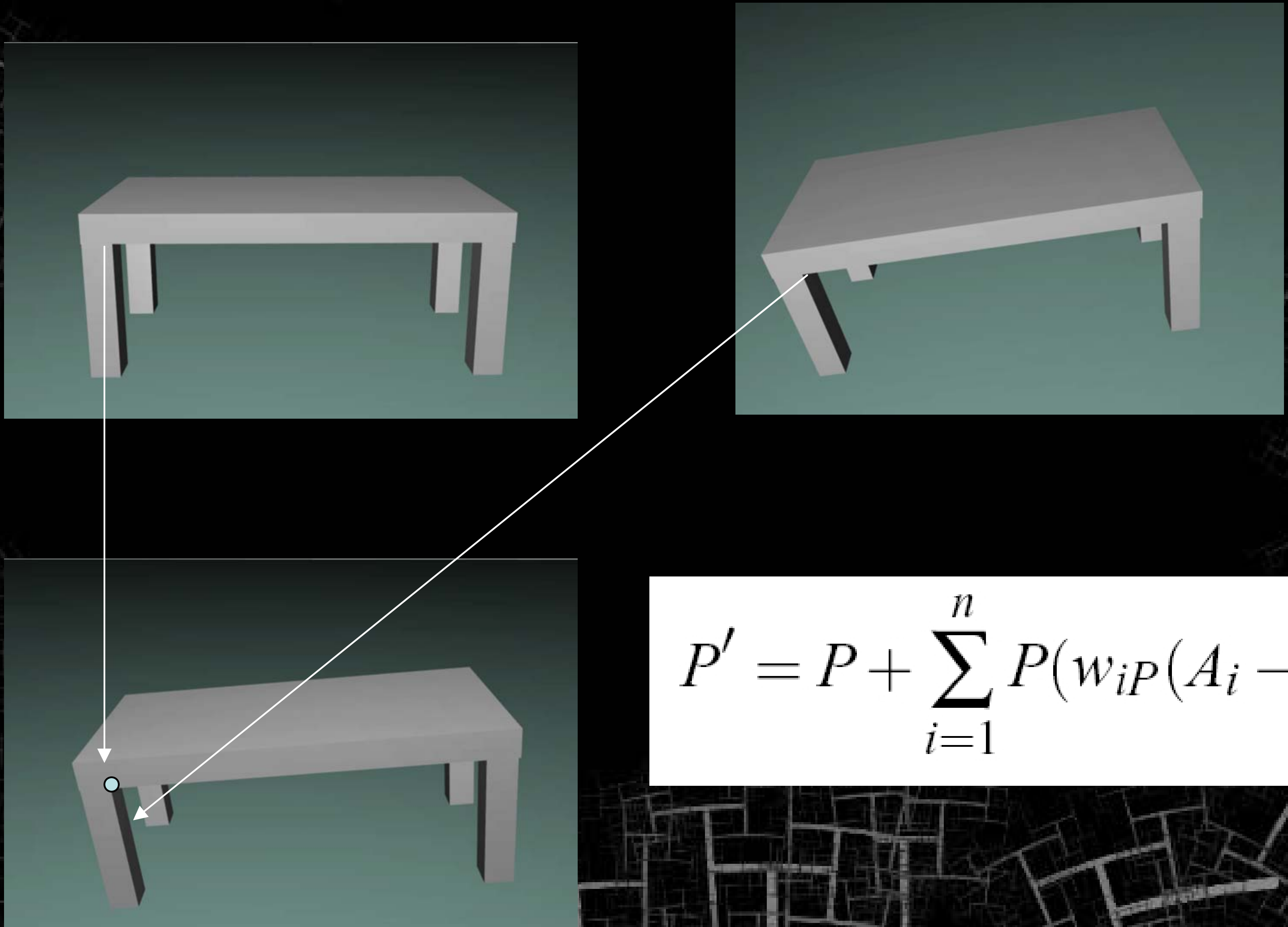
Given weight $w_i(P)$ for lackey camera *i,* point *P* deforms to *P' :*

$$P' = P + P\left(w_{iP}\left(A_i - I\right)\right)$$

…and for many lackey cameras

$$P' = P + \sum_{i=1}^{n} P\left(w_{iP}\left(A_i - I\right)\right).$$

# Two Camera Example



$$P' = P + \sum_{i=1}^{n} P(w_{iP}(A_i - I)).$$

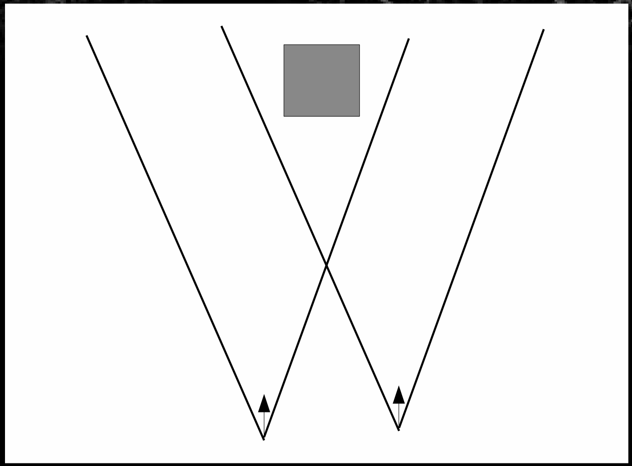
# Constraints

No Constraints

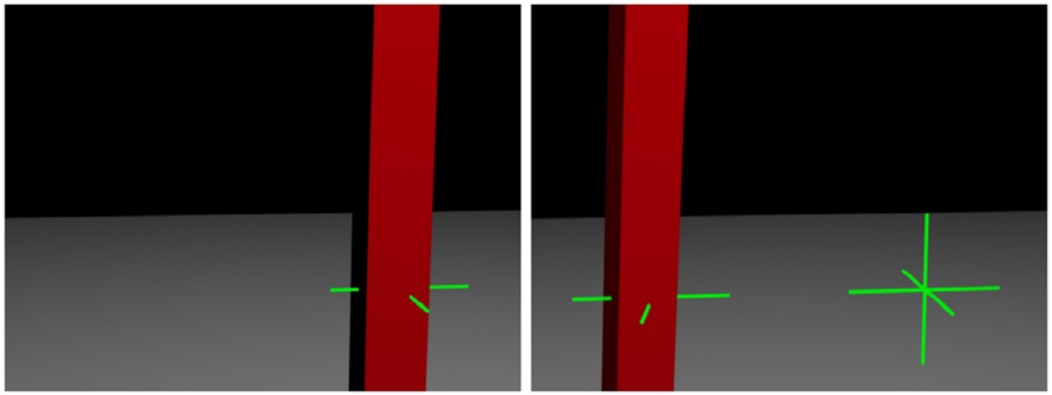
With Constraints

# Constraints

Local control of composition



Independent of projection



(a) Pillar, $R_t$ (lackey view)

(b) Constraint deformed pillar, $R_t$, $R_f$ (boss view)

# Constraints

To see constraint frame $R_f$ in lackey as $R_t$ in boss camera *:*

$$Con = (Cartesianize(R_f C_i M_i V_i))^{-1} Cartesianize(R_t C_b M_b V_b)$$

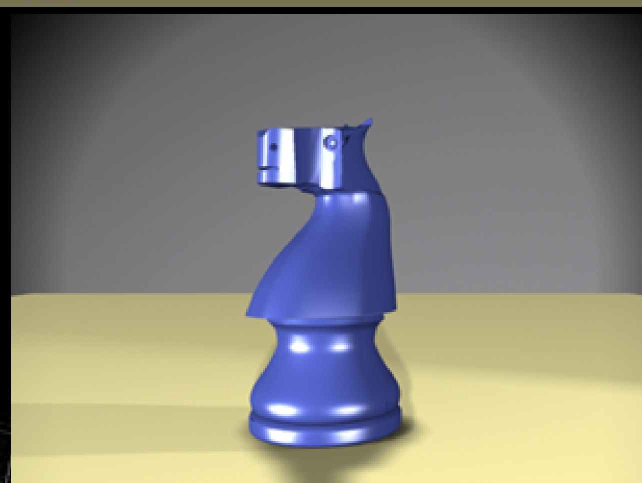
…where *Con* is a constraint matrix such that

$$A_i = C_i M_i V_i (Con)(C_b M_b V_b)^{-1}.$$

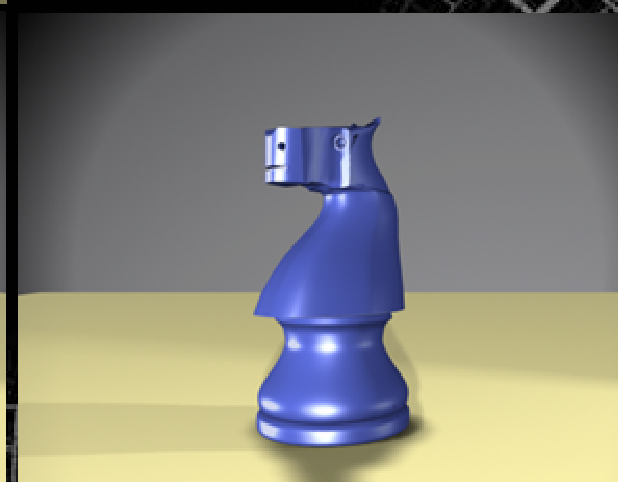
…in general *Con* is defined as an RBF interpolation of multiple constraints per scene object, per camera.

# Multiview Illumination


Boss camera shading

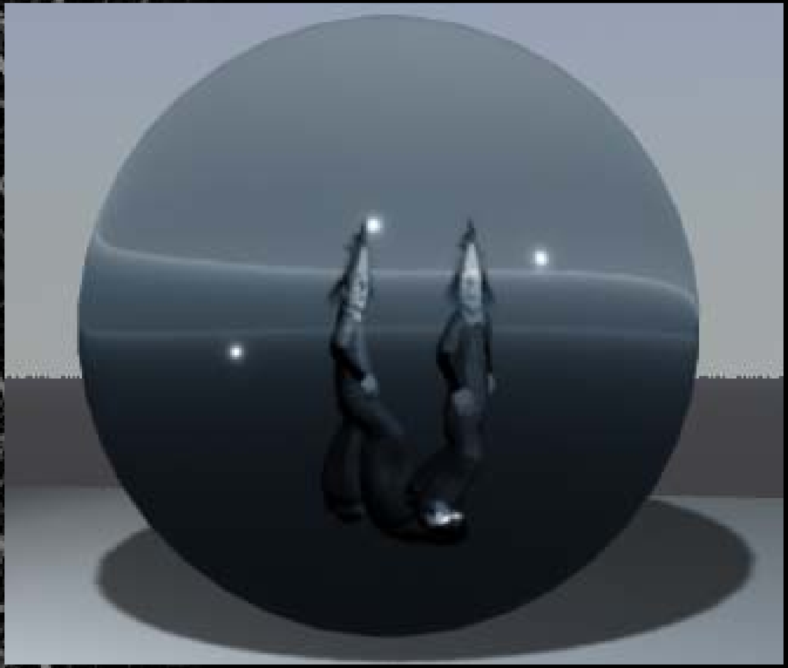


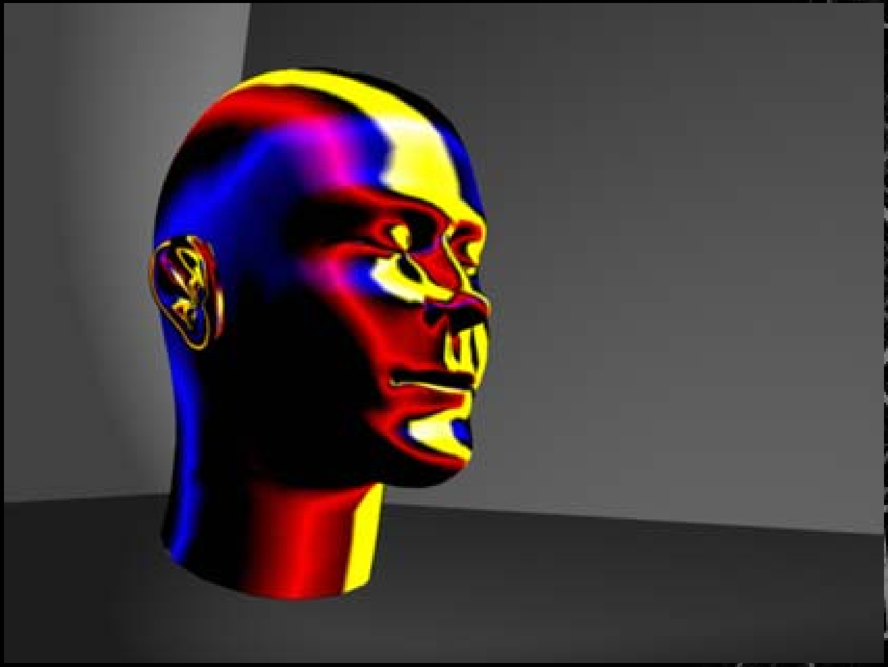
Virtual camera shading



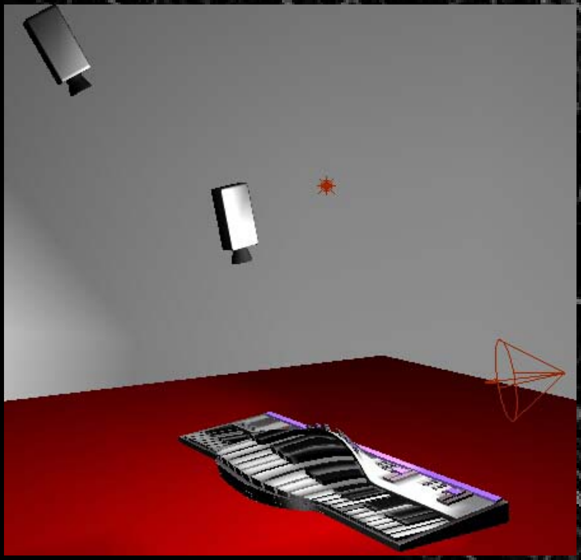
Blended shading

# Stylized Multiview Shading





# Shadows



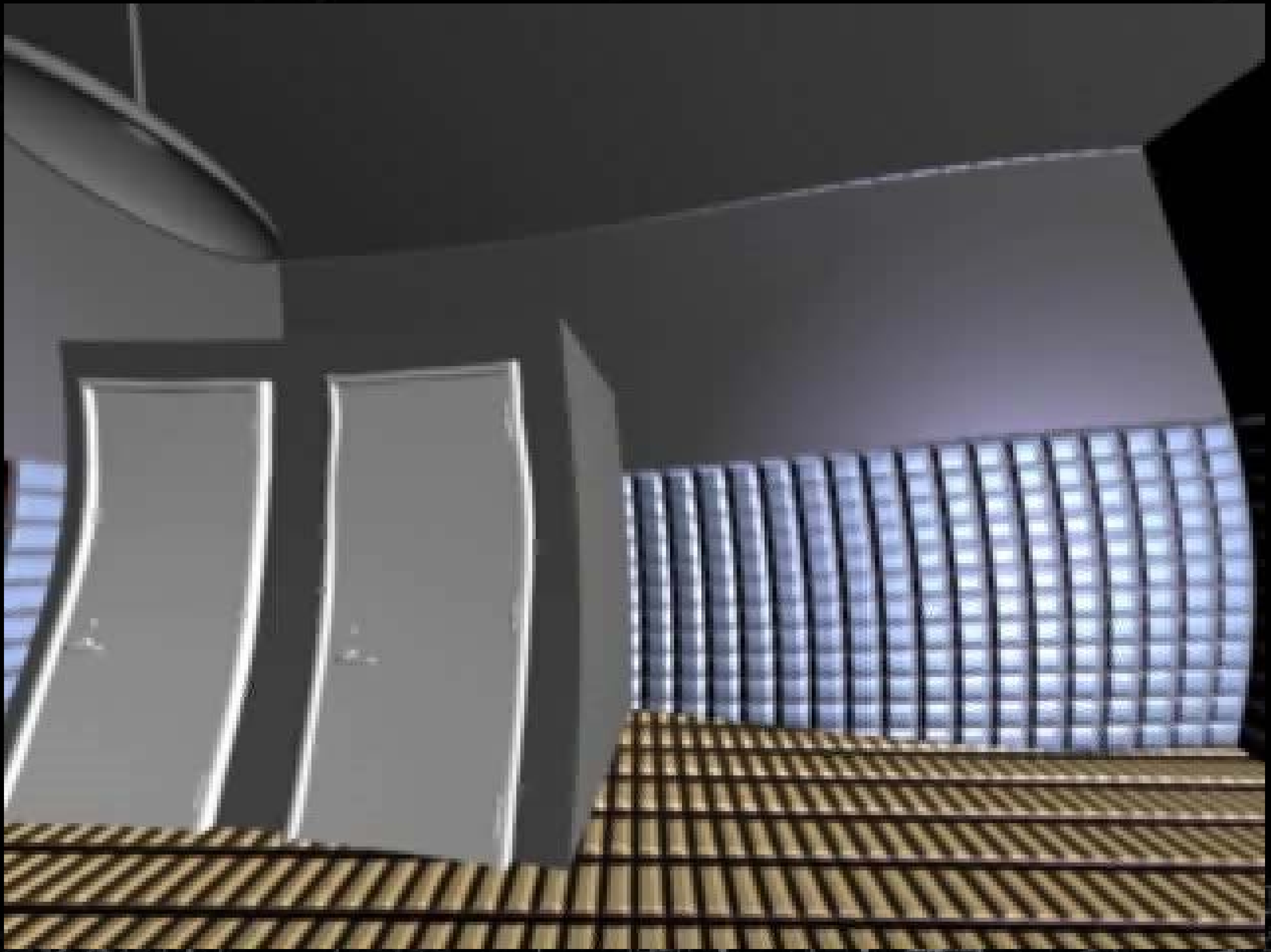
**Wrong shadows**

**Corrected shadows**

# Multiple Linear Projections

# Nonlinear Projections

# *Ryan* Test



# Ryan

# Ryan

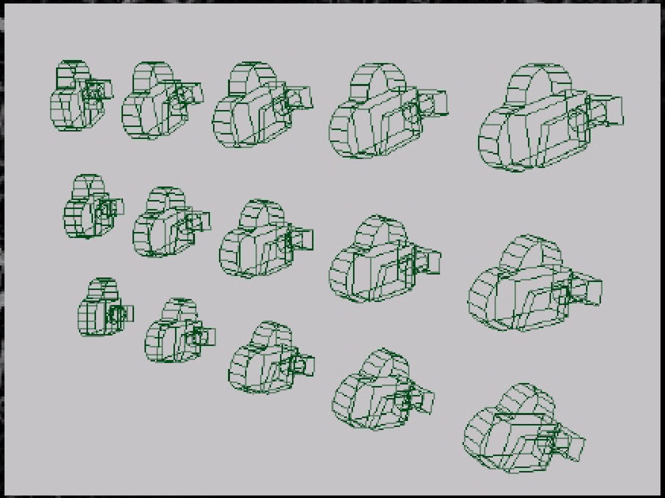
# Conclusions

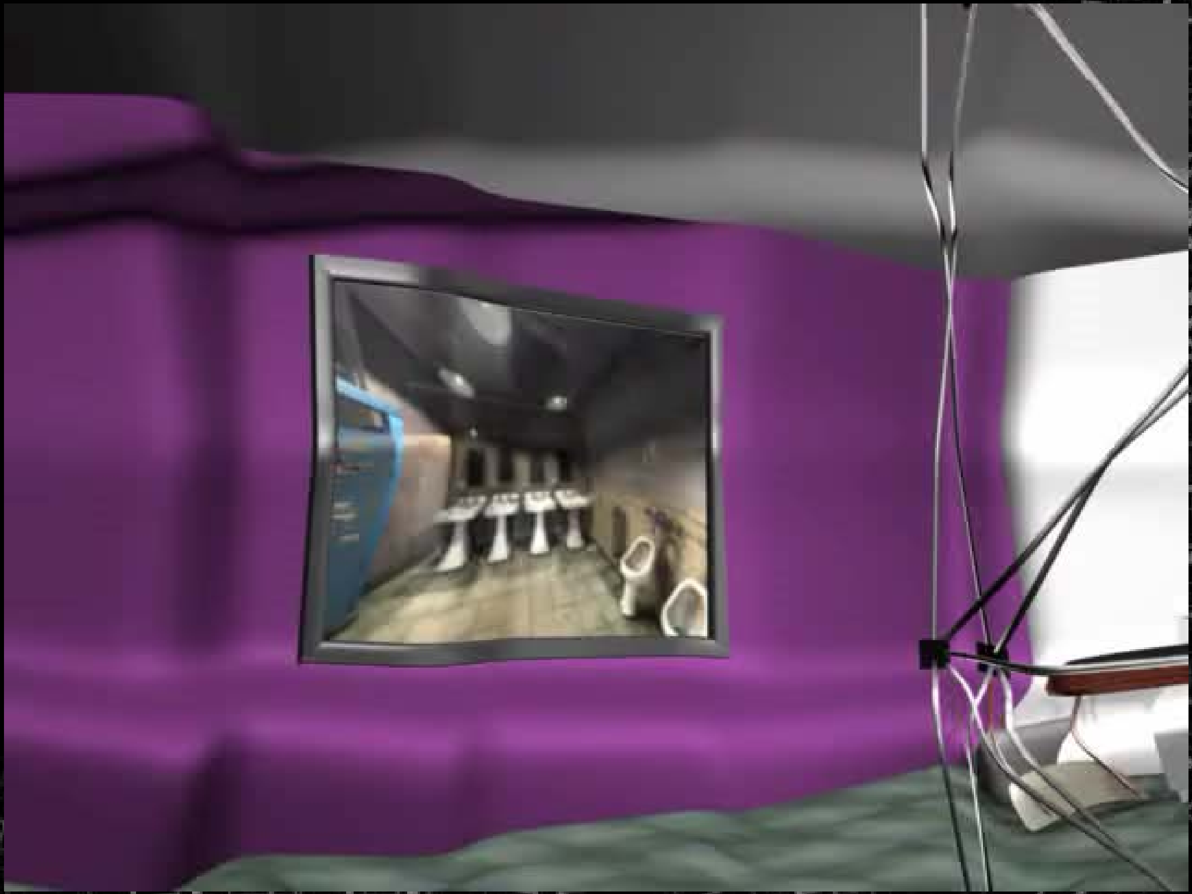
- Interactive nonlinear projection of complex scenes with animated camera
- Global and local composition and relative depth control
- Illumination and shading from multiple viewpoints

# Future Work

- Full unwrapping
- High level artist control
- Automatic camera specification

# Hierarchical nonlinear projections





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