Virtual Experiments as a Tool for Active Engagement

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Context Cues and Knowledge Development

A context setting often contains multiple cues that can each activate associations with different pieces of knowledge.

In current instruction:

- Only abstract cues of physical representations used by the instructors are seriously addressed in class:
  - Often discussed in isolated situations.
  - Students only get fragmented pieces rather than a integrative understanding.
- Cues in real life experience are often ignored:
  - Visual cues of a moving object.
  - Auditory cues associated with moving/vibrating objects.
  - Haptic cues of pushing an object.

Advantages of Using a Virtual Experiment

Flexible control of multiple context cues which are otherwise difficult to manipulate in real life situations:

- *Human response time*
- *Physical limits*
- *Integration of multiple representations*
- *Near-real environment with easy-to-change variables*
  - *More explorations in a given time*
  - *Fewer technical based frustrations*

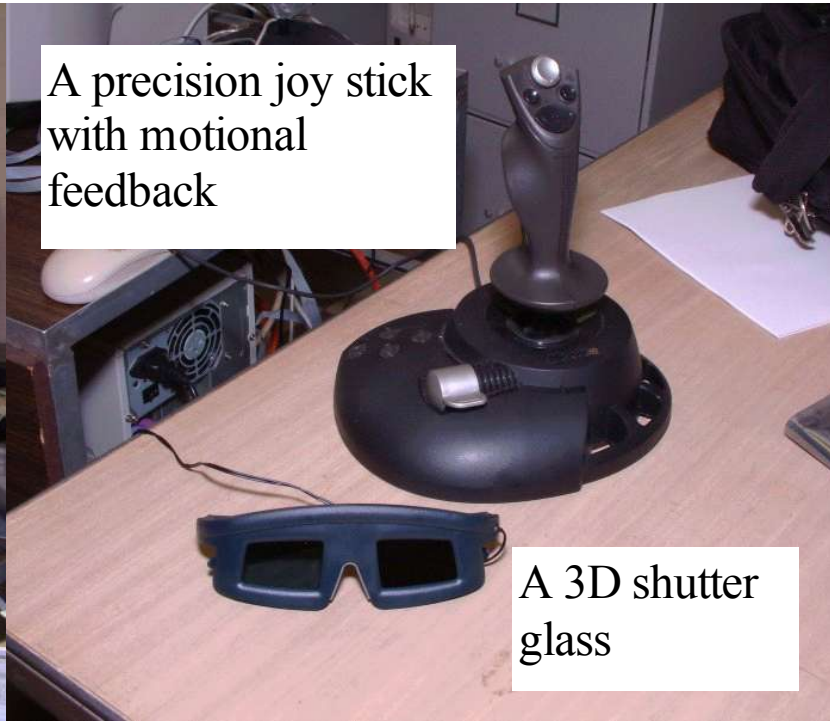
Virtual Experiment v.s. Existing Simulations

	Virtual Experiments	Existing Simulations
Visual Display	Real 3D and stereovision	Usually 2D or simulated 3D
Interactive input channels	Real-time interactive force input using the same human motor actions.	Single value "text box"
Interactive feedback channels	Force and vibration feedback Real 3D dynamic vision	
Interactive mode	Actions and feedback change in real time with the input.	Usually only allow pre-determined patterns.
Support for free exploration	It is like a real environment so anything could happen in real settings will happen given the appropriate condition. It allows open exploration.	Usually the program limits to phenomenon under many constraints.

Context Cues Addressed in Current VE Activities

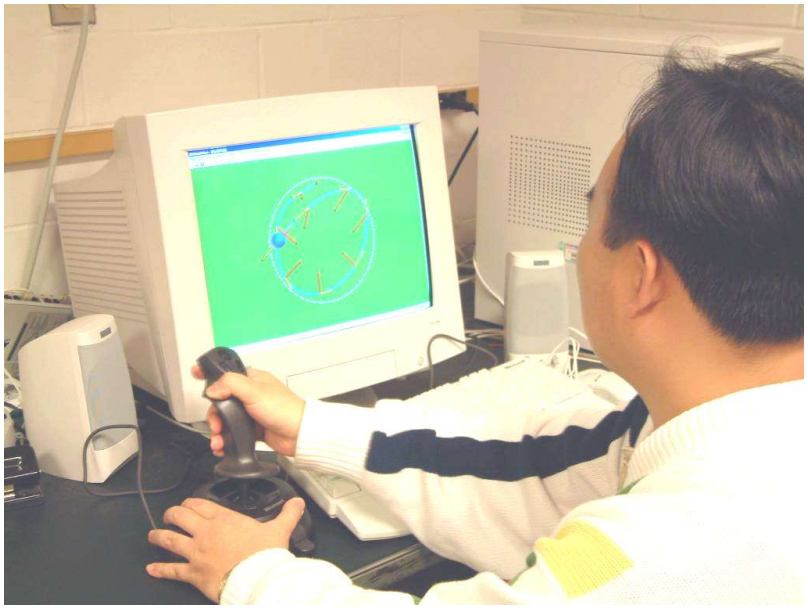
- Haptic Cues:
  - Feeling of forces exerted on an object from different directions and magnitudes: being “hit”, vibration, etc.
  - Maintaining a force in different directions and magnitudes: pushing/dragging an object with and without friction.
- Visual Cues:
  - Real 3D (with shutter glasses) of motion
  - Integrated multiple numerical and graphical representations
  - Scenery resembling real world situations

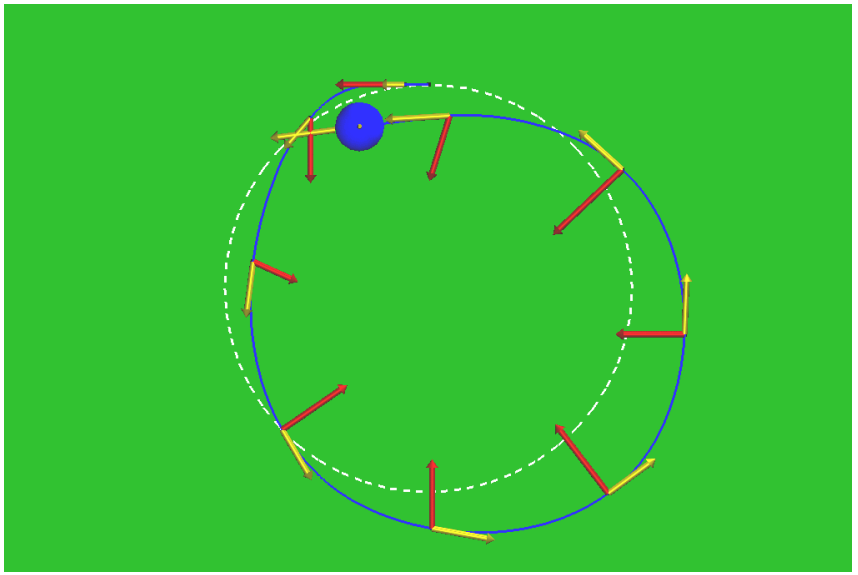
Hardware Used in Current VE Activities



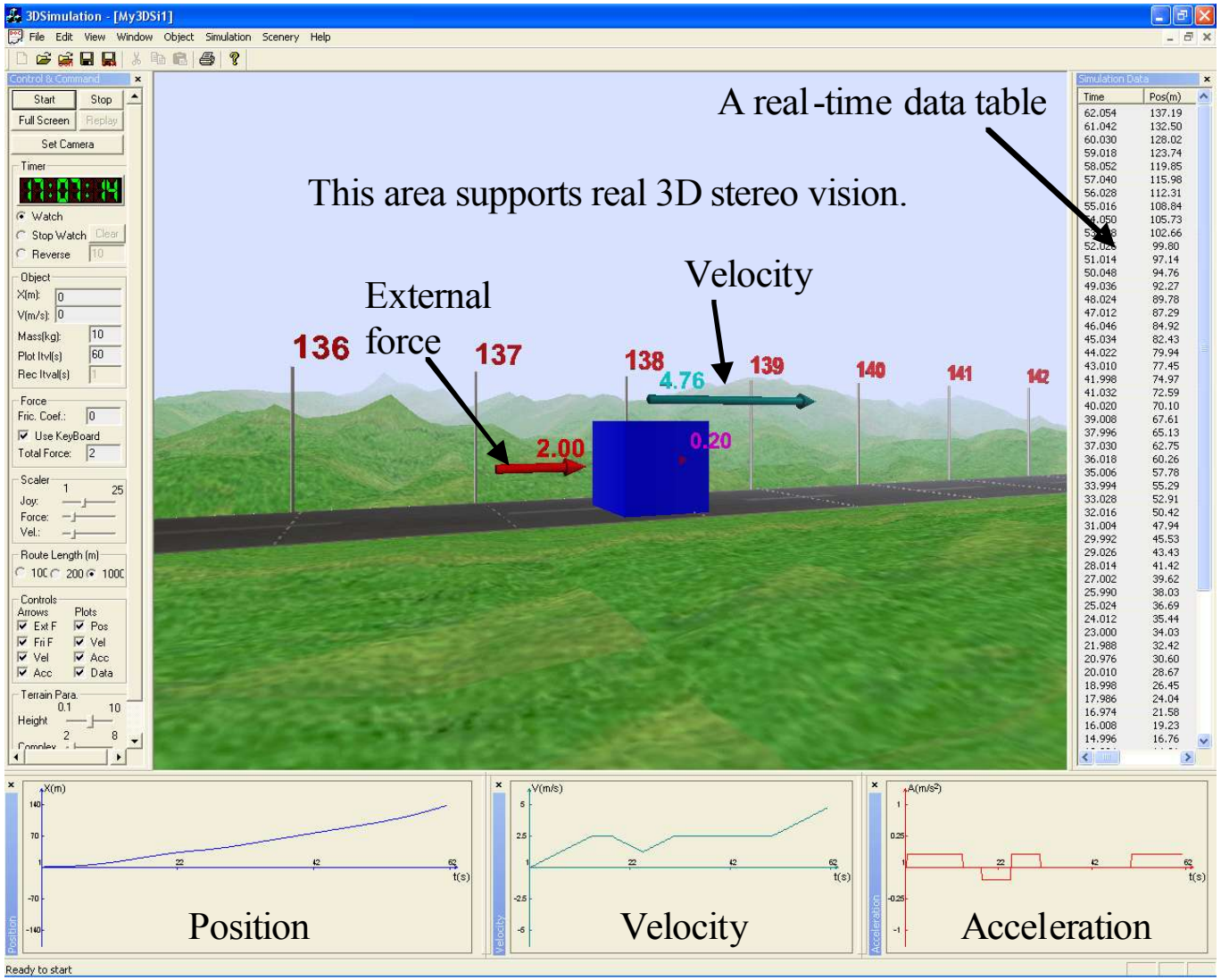
Virtual Experiment Examples

- Circular Motion:
  Interactive associations between the *feelings* and *controls* of the *magnitudes* and *directions* of *forces* and the *visual* feedback of the real-time *velocity* and *trajectory* of the motion.

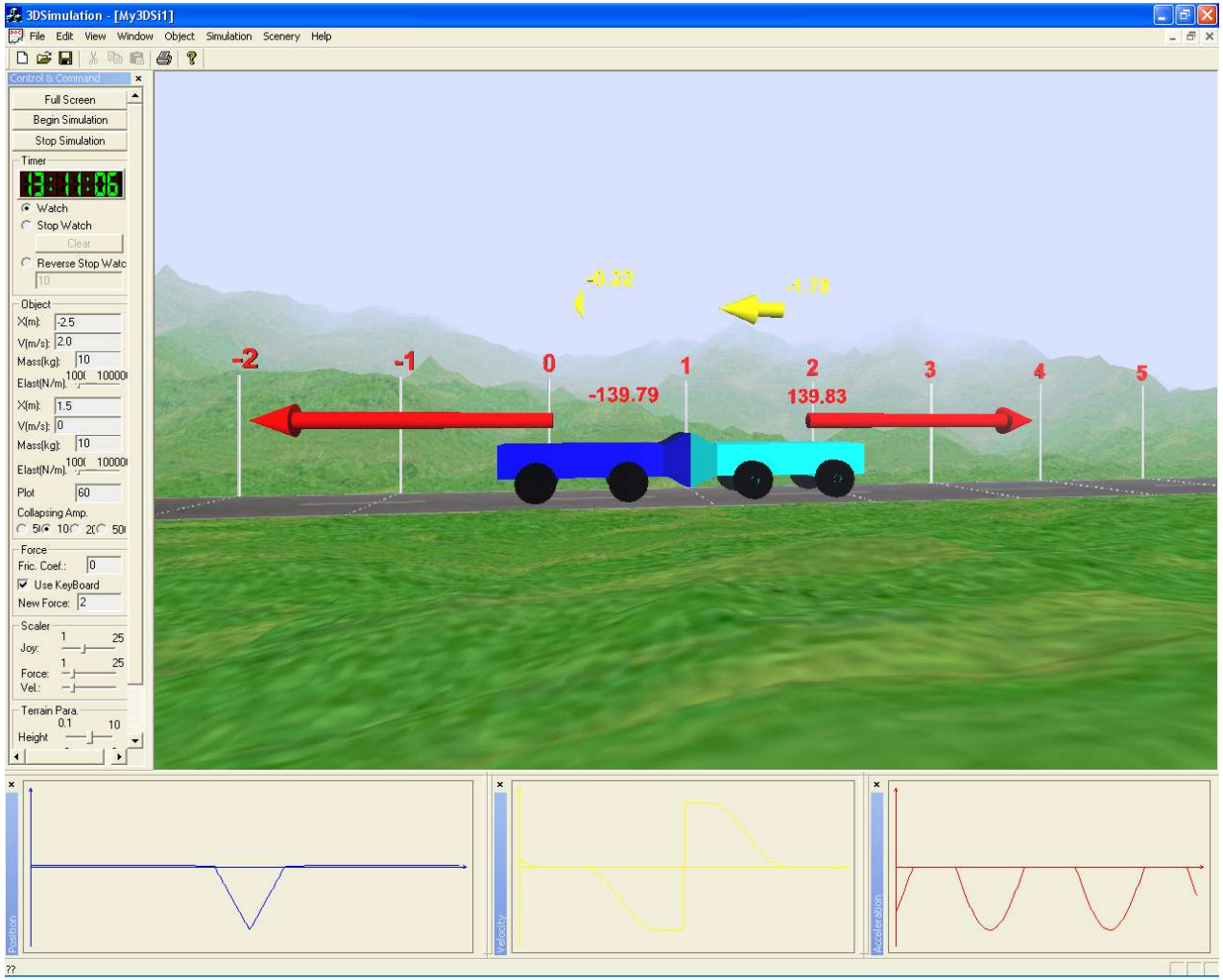




- 1-D Linear Motion:
  Major "Misconception" – "*Motion indicates force*".



- Collision:
  Major "Misconception" – Newton's Third Law



Example: Collision and Newton's 3rd Law

- Contextual Issues Addressed:
  - Mass
  - Velocity
  - Elasticity
- Methods
  - Slow motion to help visualize the process during the collision.
  - Real-time diagrams
  - Multiple representations with vectors.

Example: Collision and Newton's 3rd Law

- Tutorial-like worksheet for 1-hour interactive hands-on sessions using the VR
  - Ask students to predict the interacting forces and the various diagrams under different circumstances:
    - Different mass
    - Different velocity
    - Different elasticity
    - Different stages during the collision
      - (e.g. ask when the forces will be largest during the collision?)
  - Ask students to explore the VR to compare with their predictions and to construct correct understandings.

Results

- Several students (4/10) made inappropriate predictions about the interactive forces during the process of the collision.
- Their reasoning explicitly involves the contextual features addressed in the VE.
- All the students we tested were able to develop the correct understanding by themselves after working through the VE with the tutorial sheet.

Student Reactions to Using VE

- Many students have complains about the current lab over the years.
  - Technical issues
  - Disconnection between labs and instruction
- The group of students (~10) we tested all prefer to use VE.
  - Knowing what they are doing
  - Easy to handle (no technical problems)
  - Easy to explore different situations

Current Development

- We are developing 5 lab modules using the three VE programs.
- We will alternate real and virtual experiments in the labs.
- New labs will be implemented in our intro level mechanics courses in the spring of 2004.