1
00:00:08,400 --> 00:00:06,839
this video illustrates the efforts of a

2
00:00:09,900 --> 00:00:08,410
team of visualization and civil

3
00:00:11,970 --> 00:00:09,910
engineering researchers towards

4
00:00:14,939 --> 00:00:11,980
producing a high fidelity visualization

5
00:00:17,640 --> 00:00:14,949
of the September 11 2001 attack on the

6
00:00:19,970 --> 00:00:17,650
World Trade Center the visualization had

7
00:00:23,070 --> 00:00:19,980
to be eloquent to the non expert user

8
00:00:25,109 --> 00:00:23,080
the simulation was placed into context

9
00:00:28,439 --> 00:00:25,119
by modeling and importing the buildings

10
00:00:30,990 --> 00:00:28,449
of the WTC Plaza shown here color into a

11
00:00:33,150 --> 00:00:31,000
Google Earth model of lower Manhattan a

12
00:00:35,790 --> 00:00:33,160
finite element analysis simulation of

13
00:00:37,860 --> 00:00:35,800

the impact between the Boeing 767 and

14
00:00:39,569 --> 00:00:37,870
the top 20 floors of the North Tower was

15
00:00:42,329 --> 00:00:39,579
completed using a state-of-the-art

16
00:00:44,129 --> 00:00:42,339
simulation code then the simulation

17
00:00:45,989 --> 00:00:44,139
result were imported into a

18
00:00:48,299 --> 00:00:45,999
state-of-the-art animation system where

19
00:00:50,160 --> 00:00:48,309
the visualization was produced the

20
00:00:52,069 --> 00:00:50,170
simulation track the impact over

21
00:00:55,169 --> 00:00:52,079
three-quarters of a second real-time

22
00:00:59,610 --> 00:00:55,179
this sequence is 13 times slower than

23
00:01:01,919 --> 00:00:59,620
real-time all the animated geometry seen

24
00:01:11,580 --> 00:01:01,929
here was created automatically from the

25
00:01:11,590 --> 00:01:19,820
you

26
00:01:24,470 --> 00:01:22,370
this sequence visualizes the aircraft

27
00:01:30,399 --> 00:01:24,480
trajectory between the facade and the

28
00:01:36,830 --> 00:01:32,890
notice the oscillation of the ceiling

29
00:01:41,389 --> 00:01:39,319
this reverse angle shot visualizes the

30
00:01:44,630 --> 00:01:41,399
important damage sustained by some of

31
00:01:46,880 --> 00:01:44,640
the core colors using a camera with a

32
00:01:49,130 --> 00:01:46,890
distant header plane this sequence

33
00:01:55,350 --> 00:01:49,140
simultaneously visualizes the two floors

34
00:01:59,670 --> 00:01:57,660
notice the right engine titanium shaft

35
00:02:08,929 --> 00:01:59,680
which traverses the building virtually

36
00:02:20,350 --> 00:02:12,250
plane debris re-emerges on the office

37
00:02:20,360 --> 00:02:22,630
you

38
00:02:27,370 --> 00:02:25,030

the jet fuel in the central and two wing

39
00:02:30,820 --> 00:02:27,380
tanks was simulated using smoothest

40
00:02:32,770 --> 00:02:30,830
particle hydrodynamics or SPH nearby

41
00:02:35,170 --> 00:02:32,780
fuel particles were lumped together in

42
00:02:36,550 --> 00:02:35,180
the animation system and the fuel was

43
00:02:38,920 --> 00:02:36,560
rendered with reflections and

44
00:02:41,170 --> 00:02:38,930
refractions using a ray trace material

45
00:02:43,540 --> 00:02:41,180
notice how the wing tank fuel disperses

46
00:02:49,780 --> 00:02:43,550
first as the wings are considerably

47
00:02:53,220 --> 00:02:51,910
the core volumes are essential to the

48
00:02:55,960 --> 00:02:53,230
structural integrity of the building

49
00:02:58,149 --> 00:02:55,970
this sequence visualizes the damage the

50
00:03:00,580 --> 00:02:58,159
core columns and - they're connecting

51
00:03:12,080 --> 00:03:00,590
horizontal beams by rendering all other

52
00:03:12,090 --> 00:03:17,059
here are the core columns exclusively

53
00:03:21,470 --> 00:03:19,640
these sequences also turn out to provide

54
00:03:23,989 --> 00:03:21,480
a good visualization of the overall

55
00:03:33,100 --> 00:03:23,999
deformation of the aircraft as it enters

56
00:03:37,520 --> 00:03:35,660
the simulation did not consider the

57
00:03:40,220 --> 00:03:37,530
effects of the explosion and of the

58
00:03:42,530 --> 00:03:40,230
ensuing fire here the fuel particles

59
00:03:44,780 --> 00:03:42,540
were used in the animation system to

60
00:03:47,810 --> 00:03:44,790
automatically produce a plausible fire

61
00:03:49,670 --> 00:03:47,820
visualization as can be seen in this

62
00:03:51,800 --> 00:03:49,680
side-by-side visualization the

63
00:03:59,060 --> 00:03:51,810

simulation fuel particles control the

64
00:04:03,570 --> 00:04:01,440
elements that undergo it assists stress

65
00:04:06,420 --> 00:04:03,580
are eliminated from the computation by

66
00:04:08,280 --> 00:04:06,430
the FEI a simulation code is eroding

67
00:04:10,470 --> 00:04:08,290
elements correspond to entities that

68
00:04:13,080 --> 00:04:10,480
disintegrate such as a slab of concrete

69
00:04:14,880 --> 00:04:13,090
turning into dust although they do not

70
00:04:17,520 --> 00:04:14,890
have much relevance from the simulation

71
00:04:20,430 --> 00:04:17,530
standpoint eroded elements are important

72
00:04:22,080 --> 00:04:20,440
for the visualization eroded elements

73
00:04:24,120 --> 00:04:22,090
are using the animation system to

74
00:04:30,410 --> 00:04:24,130
automatically create and control visual

75
00:04:34,460 --> 00:04:32,510
produced leverages the strengths of a

76
00:04:36,470 --> 00:04:34,470
state-of-the-art simulation system which

77
00:04:39,230 --> 00:04:36,480
models the interactions in detail based

78
00:04:41,180 --> 00:04:39,240
on physics first-order principles and of

79
00:04:43,520 --> 00:04:41,190
a state-of-the-art animation system

80
00:04:46,790 --> 00:04:43,530
which produces a high-quality ization of

81
00:04:48,920 --> 00:04:46,800
the simulation results this was made

82
00:04:50,810 --> 00:04:48,930
possible by developing a scalable

83
00:04:52,610 --> 00:04:50,820
translator that automatically converts

84
00:04:55,580 --> 00:04:52,620
the simulation output data into an

85
00:04:57,860 --> 00:04:55,590
animation see the translator is general