
sion Laboratory
ttitute of Technology

1
00:00:03,990 --> 00:00:02,389
nasa's jet propulsion laboratory

2
00:00:06,630 --> 00:00:04,000
presents

3
00:00:08,710 --> 00:00:06,640
the von carmen lecture a series of talks

4
00:00:11,990 --> 00:00:08,720
by scientists and engineers who are

5
00:00:27,109 --> 00:00:12,000
exploring our planet our solar system

6
00:00:31,109 --> 00:00:28,870
good evening ladies and gentlemen how's

7
00:00:32,150 --> 00:00:31,119
everyone tonight

8
00:00:33,670 --> 00:00:32,160
good

9
00:00:34,709 --> 00:00:33,680
well thanks for coming out to join us as

10
00:00:36,870 --> 00:00:34,719
always

11
00:00:38,310 --> 00:00:36,880
jpl has been engaged in several programs

12
00:00:40,310 --> 00:00:38,320
over the last few years that have

13
00:00:42,069 --> 00:00:40,320

developed new robots and software that

14
00:00:44,630 --> 00:00:42,079
can help out in terrestrial disaster

15
00:00:46,630 --> 00:00:44,640
scenarios or hazardous environments

16
00:00:48,470 --> 00:00:46,640
in particular the robo-simeon and

17
00:00:50,869 --> 00:00:48,480
surrogate sibling robots have been

18
00:00:52,630 --> 00:00:50,879
diagnosed or designed rather to move

19
00:00:54,790 --> 00:00:52,640
through human environments after humans

20
00:00:56,709 --> 00:00:54,800
have had to evacuate and execute key

21
00:00:59,270 --> 00:00:56,719
manipulation tasks that will ameliorate

22
00:01:01,110 --> 00:00:59,280
the situation robo simeon will be put to

23
00:01:03,349 --> 00:01:01,120
the test against an international field

24
00:01:05,750 --> 00:01:03,359
of robotic competitors at the darpa

25
00:01:07,830 --> 00:01:05,760
robotics challenge this june 5th and 6th

26
00:01:09,429 --> 00:01:07,840
at the pomona fairplex

27
00:01:11,270 --> 00:01:09,439
tonight's guest is currently the

28
00:01:13,830 --> 00:01:11,280
supervisor of the robotic vehicles and

29
00:01:15,590 --> 00:01:13,840
manipulators group at jpl

30
00:01:18,550 --> 00:01:15,600
his areas of expertise include space

31
00:01:21,109 --> 00:01:18,560
robotics bio-inspired robotics novel

32
00:01:23,670 --> 00:01:21,119
mobility systems robotic manipulators

33
00:01:25,990 --> 00:01:23,680
and under-actuated grippers he graduated

34
00:01:28,070 --> 00:01:26,000
from uc berkeley in 1996 with a bs in

35
00:01:30,550 --> 00:01:28,080
mechanical engineering with an emphasis

36
00:01:32,230 --> 00:01:30,560
in controls and robotics as an undergrad

37
00:01:34,550 --> 00:01:32,240
he was involved in research covering the

38
00:01:36,789 --> 00:01:34,560

design of composite material parts the

39
00:01:38,469 --> 00:01:36,799
design of human amplification mechanisms

40
00:01:41,510 --> 00:01:38,479
and the finite element

41
00:01:43,270 --> 00:01:41,520
modeling of bones in 1997 he received

42
00:01:45,030 --> 00:01:43,280
his ms in mechanical engineering from

43
00:01:47,190 --> 00:01:45,040
stanford university concentrating on

44
00:01:49,030 --> 00:01:47,200
mechatronics and robotics

45
00:01:51,190 --> 00:01:49,040
at jpl he's divided his time between

46
00:01:53,350 --> 00:01:51,200
research and space flight robotics on

47
00:01:55,350 --> 00:01:53,360
the research front he conceived and led

48
00:01:57,990 --> 00:01:55,360
the development of the bio-inspired

49
00:01:59,590 --> 00:01:58,000
lemur series of robots as well as acting

50
00:02:02,069 --> 00:01:59,600
as the lead mechanical engineer on a

51
00:02:03,830 --> 00:02:02,079
number of other robotic systems

52
00:02:05,590 --> 00:02:03,840
he has also acted as the lead robotic

53
00:02:07,830 --> 00:02:05,600
engineer on several darpa studies of

54
00:02:09,990 --> 00:02:07,840
subjects such as orbital telescopes and

55
00:02:12,070 --> 00:02:10,000
humanoid robotic mobility

56
00:02:13,670 --> 00:02:12,080
on the flight side his major role has

57
00:02:15,510 --> 00:02:13,680
been as the cognizant engineer of the

58
00:02:17,510 --> 00:02:15,520
robotic arm for the mars science

59
00:02:20,550 --> 00:02:17,520
laboratory where he was responsible for

60
00:02:22,229 --> 00:02:20,560
the design fabrication and testing

61
00:02:23,990 --> 00:02:22,239
previously he had also been responsible

62
00:02:25,430 --> 00:02:24,000
for two elements of the mars exploration

63
00:02:27,190 --> 00:02:25,440

rover chassis

64
00:02:29,110 --> 00:02:27,200
currently he is leading the development

65
00:02:31,110 --> 00:02:29,120
of the gecko gripper tool for the darpa

66
00:02:33,190 --> 00:02:31,120
phoenix flight program and the

67
00:02:35,110 --> 00:02:33,200
robo-simeon robot for darpa's robotic

68
00:02:37,110 --> 00:02:35,120
challenge ladies and gentlemen please

69
00:02:45,430 --> 00:02:37,120
help me welcome tonight's guest mr brett

70
00:02:49,990 --> 00:02:48,150
thanks mark um so today

71
00:02:52,229 --> 00:02:50,000
we're going to talk about robots that

72
00:02:53,670 --> 00:02:52,239
are here to help and

73
00:02:55,830 --> 00:02:53,680
you know really the title of this is

74
00:02:58,550 --> 00:02:55,840
robots to the rescue is more about the

75
00:02:59,990 --> 00:02:58,560
alliteration than it is literally the

76
00:03:01,509 --> 00:03:00,000
idea that robots are going to come and

77
00:03:04,070 --> 00:03:01,519
they're going to pull people out of

78
00:03:05,830 --> 00:03:04,080
burning buildings that's that's a grand

79
00:03:07,589 --> 00:03:05,840
goal but it's not really where we are

80
00:03:08,710 --> 00:03:07,599
today

81
00:03:10,070 --> 00:03:08,720
so i'm going to explain a little bit

82
00:03:11,350 --> 00:03:10,080
about what these robots are really

83
00:03:13,350 --> 00:03:11,360
designed to do and some of the

84
00:03:15,910 --> 00:03:13,360
technologies that we use to to make that

85
00:03:19,190 --> 00:03:17,910
so disaster response means mobile

86
00:03:20,149 --> 00:03:19,200
manipulation

87
00:03:20,949 --> 00:03:20,159
now

88
00:03:23,750 --> 00:03:20,959

the

89
00:03:24,470 --> 00:03:23,760
if you can get some place that

90
00:03:28,070 --> 00:03:24,480
uh

91
00:03:31,110 --> 00:03:28,080
is under a disaster scenario and do

92
00:03:33,750 --> 00:03:31,120
something key to help the situation

93
00:03:36,070 --> 00:03:33,760
that would be fantastic

94
00:03:37,910 --> 00:03:36,080
and to do that you both have to go there

95
00:03:40,070 --> 00:03:37,920
and you have to do something once you

96
00:03:42,229 --> 00:03:40,080
get there so this is actually different

97
00:03:45,350 --> 00:03:42,239
than other areas of robotics where it's

98
00:03:46,869 --> 00:03:45,360
mostly about the going or places or

99
00:03:47,990 --> 00:03:46,879
areas of robotics it's mostly about the

100
00:03:50,390 --> 00:03:48,000
doing so

101
00:03:51,509 --> 00:03:50,400
quadrotors are really great at going

102
00:03:53,670 --> 00:03:51,519
places

103
00:03:56,229 --> 00:03:53,680
industrial robots robotic arms are

104
00:03:57,990 --> 00:03:56,239
really great at assembling cars this is

105
00:04:00,550 --> 00:03:58,000
something in between those two things

106
00:04:02,149 --> 00:04:00,560
and the types of technology

107
00:04:03,750 --> 00:04:02,159
sometimes it can borrow from either side

108
00:04:05,350 --> 00:04:03,760
of that spectrum and sometimes we have

109
00:04:07,589 --> 00:04:05,360
to do things differently because we need

110
00:04:09,030 --> 00:04:07,599
to both go and do

111
00:04:11,030 --> 00:04:09,040
so

112
00:04:13,270 --> 00:04:11,040
one particular emphasis tonight is going

113
00:04:15,589 --> 00:04:13,280

to be the darpa robotics challenge

114
00:04:17,670 --> 00:04:15,599
and that's a competition i'll explain a

115
00:04:18,550 --> 00:04:17,680
little bit more and it really is the

116
00:04:22,069 --> 00:04:18,560
place

117
00:04:24,870 --> 00:04:22,079
in research where mobile manipulation

118
00:04:28,469 --> 00:04:24,880
has it its highest

119
00:04:30,310 --> 00:04:28,479
expression for practical use so there's

120
00:04:32,230 --> 00:04:30,320
a lot of really interesting research

121
00:04:34,070 --> 00:04:32,240
that's more on the academic side and how

122
00:04:36,790 --> 00:04:34,080
you can do these things but here we have

123
00:04:39,670 --> 00:04:36,800
robots that really need to actually

124
00:04:41,909 --> 00:04:39,680
make things happen in real time and in

125
00:04:43,830 --> 00:04:41,919
real conditions or at least mostly real

126
00:04:47,110 --> 00:04:43,840
conditions

127
00:04:49,270 --> 00:04:47,120
so jpl's effort here robosimian

128
00:04:51,350 --> 00:04:49,280
both refers to a robot and as i'm going

129
00:04:53,510 --> 00:04:51,360
to explain it also

130
00:04:57,510 --> 00:04:53,520
describes a set of technologies that we

131
00:04:58,710 --> 00:04:57,520
can use for various purposes

132
00:05:00,310 --> 00:04:58,720
okay so

133
00:05:03,990 --> 00:05:00,320
let's set up the problem a little bit

134
00:05:05,510 --> 00:05:04,000
the what is the robotics challenge

135
00:05:07,670 --> 00:05:05,520
so that's a lot of words this is what

136
00:05:10,070 --> 00:05:07,680
darpa says the robotics challenge is

137
00:05:11,909 --> 00:05:10,080
but really it's these words in yellow

138
00:05:13,909 --> 00:05:11,919

that are important it's a mobility and

139
00:05:15,430 --> 00:05:13,919
dexterity maneuver in degraded

140
00:05:17,749 --> 00:05:15,440
environments typical of disaster zones

141
00:05:19,830 --> 00:05:17,759
so otherwise known as humans built

142
00:05:21,830 --> 00:05:19,840
something and it fell down

143
00:05:26,469 --> 00:05:21,840
and then

144
00:05:28,310 --> 00:05:26,479
to be able to deal with tools and jobs

145
00:05:33,029 --> 00:05:28,320
that are sort of of the nature of what a

146
00:05:37,350 --> 00:05:34,070
and

147
00:05:39,430 --> 00:05:37,360
december 2013 we took part in the darpa

148
00:05:42,070 --> 00:05:39,440
robotics challenge trials

149
00:05:43,749 --> 00:05:42,080
those trials are laid out here

150
00:05:45,670 --> 00:05:43,759
and this gives you a feel for the

151
00:05:48,550 --> 00:05:45,680
general scenario now

152
00:05:50,950 --> 00:05:48,560
to set this up in particular

153
00:05:54,070 --> 00:05:50,960
the entire challenge was

154
00:05:55,110 --> 00:05:54,080
inspired by the fukushima disaster

155
00:05:56,629 --> 00:05:55,120
and

156
00:05:58,070 --> 00:05:56,639
in fukushima

157
00:06:00,150 --> 00:05:58,080
there

158
00:06:01,909 --> 00:06:00,160
were a couple of things very simple

159
00:06:03,990 --> 00:06:01,919
things that had they been done would

160
00:06:05,350 --> 00:06:04,000
have limited the damage overall now this

161
00:06:07,909 --> 00:06:05,360
is something that has affected people

162
00:06:09,110 --> 00:06:07,919
worldwide and had a robot been able to

163
00:06:10,950 --> 00:06:09,120

go into

164
00:06:13,029 --> 00:06:10,960
some of the reactor spaces

165
00:06:14,070 --> 00:06:13,039
and done something as simple as turning

166
00:06:16,070 --> 00:06:14,080
a valve

167
00:06:18,390 --> 00:06:16,080
that would have released some hydrogen

168
00:06:20,870 --> 00:06:18,400
that had accumulated and would have

169
00:06:22,870 --> 00:06:20,880
prevented secondary explosions that

170
00:06:24,870 --> 00:06:22,880
caused a lot of the damage

171
00:06:26,790 --> 00:06:24,880
because there was not a robot that could

172
00:06:28,230 --> 00:06:26,800
go someplace and do something as simple

173
00:06:29,270 --> 00:06:28,240
as turn a valve

174
00:06:30,309 --> 00:06:29,280
there was

175
00:06:31,749 --> 00:06:30,319
all of this

176
00:06:32,950 --> 00:06:31,759
additional damage

177
00:06:35,029 --> 00:06:32,960
so

178
00:06:37,830 --> 00:06:35,039
inspired by this darpa created the darpa

179
00:06:39,270 --> 00:06:37,840
robotics challenge and as you can see

180
00:06:41,350 --> 00:06:39,280
it starts out with the idea that the

181
00:06:42,950 --> 00:06:41,360
robot needs to get to the location now

182
00:06:44,309 --> 00:06:42,960
darpa has chosen a particularly

183
00:06:46,150 --> 00:06:44,319
interesting way of doing that which is

184
00:06:49,590 --> 00:06:46,160
to say the robot needs to get into a

185
00:06:52,550 --> 00:06:49,600
human vehicle and drive it

186
00:06:54,469 --> 00:06:52,560
and then get out of it now does a robot

187
00:06:56,070 --> 00:06:54,479
really need to get into a vehicle to get

188
00:06:57,830 --> 00:06:56,080

someplace

189
00:06:59,350 --> 00:06:57,840
that's arguable we have robots that

190
00:07:02,550 --> 00:06:59,360
would actually roll themselves to the

191
00:07:04,629 --> 00:07:02,560
location but as a problem it's very

192
00:07:07,270 --> 00:07:04,639
interesting because it is a very human

193
00:07:08,710 --> 00:07:07,280
structured problem to deal with the

194
00:07:10,309 --> 00:07:08,720
inside of a vehicle it's really just

195
00:07:11,110 --> 00:07:10,319
designed around people and for no other

196
00:07:13,189 --> 00:07:11,120
reason

197
00:07:16,390 --> 00:07:13,199
so if you can drive a vehicle then you

198
00:07:19,189 --> 00:07:16,400
can do a bunch of other things as well

199
00:07:21,589 --> 00:07:19,199
after it gets out it walks across

200
00:07:22,790 --> 00:07:21,599
debris sort of a

201
00:07:24,469 --> 00:07:22,800
rough terrain

202
00:07:25,990 --> 00:07:24,479
and then it needs to get inside the

203
00:07:27,589 --> 00:07:26,000
building now the assumption again is

204
00:07:29,990 --> 00:07:27,599
that this is a degraded environment i.e

205
00:07:32,230 --> 00:07:30,000
things have fallen down so it needs to

206
00:07:33,749 --> 00:07:32,240
reach in and grab things and move them

207
00:07:35,589 --> 00:07:33,759
out of the way of a door

208
00:07:38,390 --> 00:07:35,599
that goes through the door

209
00:07:41,510 --> 00:07:38,400
climbs the ladder cuts through a wall

210
00:07:43,189 --> 00:07:41,520
and carries a hose and then finally we

211
00:07:45,270 --> 00:07:43,199
get to the valve part of it so at the

212
00:07:46,309 --> 00:07:45,280
very end of all this

213
00:07:49,589 --> 00:07:46,319

there

214
00:07:50,950 --> 00:07:49,599
is the one task that's kind of uh

215
00:07:53,350 --> 00:07:50,960
analogous to what we would have done in

216
00:07:54,950 --> 00:07:53,360
fukushima but along the way we're trying

217
00:07:56,150 --> 00:07:54,960
to exercise all these other capabilities

218
00:07:58,869 --> 00:07:56,160
they're very

219
00:08:01,189 --> 00:07:58,879
human in nature but need to be carried

220
00:08:02,869 --> 00:08:01,199
out by a robot

221
00:08:04,790 --> 00:08:02,879
and

222
00:08:06,390 --> 00:08:04,800
all of these tasks other than the very

223
00:08:08,070 --> 00:08:06,400
direct things that they're doing they're

224
00:08:10,390 --> 00:08:08,080
also trying to exercise certain

225
00:08:12,230 --> 00:08:10,400
abilities of the robot so perception how

226
00:08:14,070 --> 00:08:12,240
does a robot see the world and take in

227
00:08:15,029 --> 00:08:14,080
that information and what does it do

228
00:08:17,350 --> 00:08:15,039
with it

229
00:08:20,629 --> 00:08:17,360
mounted mobility that's driving the car

230
00:08:22,790 --> 00:08:20,639
dexterity so what can the robot do in a

231
00:08:23,909 --> 00:08:22,800
dexterous manner and we'll talk a little

232
00:08:25,430 --> 00:08:23,919
bit about the difference between

233
00:08:27,029 --> 00:08:25,440
dexterity and just

234
00:08:29,350 --> 00:08:27,039
general manipulation

235
00:08:31,589 --> 00:08:29,360
decision making now decision making in

236
00:08:33,509 --> 00:08:31,599
this case is not necessarily the robots

237
00:08:36,230 --> 00:08:33,519
alone it's also the way the operators

238
00:08:38,790 --> 00:08:36,240

use the robot and their decisions is

239
00:08:40,870 --> 00:08:38,800
dismounted mobility so obviously when

240
00:08:42,709 --> 00:08:40,880
the robots outside the vehicle and

241
00:08:44,389 --> 00:08:42,719
strength so

242
00:08:46,230 --> 00:08:44,399
you could build a gossamer system that

243
00:08:48,470 --> 00:08:46,240
really couldn't ever do anything even

244
00:08:50,389 --> 00:08:48,480
though it could go through the motions

245
00:08:53,030 --> 00:08:50,399
and in this case we really wanted some

246
00:08:54,630 --> 00:08:53,040
systems that could put some

247
00:08:57,030 --> 00:08:54,640
actually physically interact with their

248
00:08:57,829 --> 00:08:57,040
environments

249
00:09:00,470 --> 00:08:57,839
so

250
00:09:02,630 --> 00:09:00,480
we're going on to the finals and i will

251
00:09:04,389 --> 00:09:02,640
make an unabashed plug here since you're

252
00:09:07,269 --> 00:09:04,399
all i'm pretty sure are local or

253
00:09:10,630 --> 00:09:07,279
local-ish in pomona on june 5th and 6th

254
00:09:12,790 --> 00:09:10,640
at the fairplex will be the finals uh

255
00:09:14,790 --> 00:09:12,800
there are i think at this current count

256
00:09:15,910 --> 00:09:14,800
something like 28 different teams as

257
00:09:17,990 --> 00:09:15,920
mark mentioned they're going to come

258
00:09:20,470 --> 00:09:18,000
from all over the world

259
00:09:22,230 --> 00:09:20,480
japan south korea germany

260
00:09:24,630 --> 00:09:22,240
at the very least and there are also a

261
00:09:27,269 --> 00:09:24,640
lot of homegrown teams

262
00:09:29,350 --> 00:09:27,279
both from universities and large

263
00:09:31,430 --> 00:09:29,360

companies but also some very interesting

264
00:09:32,949 --> 00:09:31,440
teams from people who are just

265
00:09:34,389 --> 00:09:32,959
trying to build interesting robots in

266
00:09:37,190 --> 00:09:34,399
their garage

267
00:09:39,190 --> 00:09:37,200
so uh you can come see the the wide

268
00:09:40,710 --> 00:09:39,200
spectrum of folks that are going to show

269
00:09:42,150 --> 00:09:40,720
up to to do this

270
00:09:44,389 --> 00:09:42,160
and if you want more information

271
00:09:46,150 --> 00:09:44,399
roboticschallenge.org

272
00:09:48,630 --> 00:09:46,160
we'll we'll get that information to you

273
00:09:51,829 --> 00:09:48,640
it is completely open to the public

274
00:09:54,630 --> 00:09:51,839
and uh it's really set up as a spectator

275
00:09:57,350 --> 00:09:54,640
sport that really is what a darpa is uh

276
00:09:59,509 --> 00:09:57,360
hoping for here so tell your friends

277
00:10:02,230 --> 00:09:59,519
bring yourselves

278
00:10:03,190 --> 00:10:02,240
yeah it's cool okay

279
00:10:06,630 --> 00:10:03,200
so

280
00:10:09,269 --> 00:10:07,590
well

281
00:10:13,829 --> 00:10:09,279
anybody

282
00:10:15,829 --> 00:10:13,839
or had a kid

283
00:10:17,990 --> 00:10:15,839
all right yes

284
00:10:21,670 --> 00:10:18,000
so you're probably familiar with a

285
00:10:23,350 --> 00:10:21,680
certain little curious monkey

286
00:10:24,870 --> 00:10:23,360
as you've already gotten from the name

287
00:10:25,990 --> 00:10:24,880
robosimian

288
00:10:29,590 --> 00:10:26,000

is

289
00:10:33,350 --> 00:10:29,600
inspired by our simian cousins apes and

290
00:10:34,949 --> 00:10:33,360
and monkeys and i really while i didn't

291
00:10:36,389 --> 00:10:34,959
use these particular pictures as

292
00:10:37,910 --> 00:10:36,399
inspiration as i was reading these

293
00:10:41,430 --> 00:10:37,920
stories to my daughter i'm like that's

294
00:10:43,190 --> 00:10:41,440
exactly what we're talking about here so

295
00:10:44,870 --> 00:10:43,200
really a generalized system and when i

296
00:10:47,430 --> 00:10:44,880
say a generalized system

297
00:10:49,910 --> 00:10:47,440
people are not a generalized system we

298
00:10:52,389 --> 00:10:49,920
have very distinct legs our legs are

299
00:10:54,710 --> 00:10:52,399
good for walking they're reasonably okay

300
00:10:56,550 --> 00:10:54,720
for running we've got arms that are

301
00:10:57,910 --> 00:10:56,560
really good for grabbing things hands

302
00:11:00,470 --> 00:10:57,920
that are really good at holding on to

303
00:11:03,750 --> 00:11:00,480
things and and doing dexterous

304
00:11:05,910 --> 00:11:03,760
manipulation with your hands

305
00:11:07,430 --> 00:11:05,920
but we're what biologists refer to as a

306
00:11:08,710 --> 00:11:07,440
derived

307
00:11:11,190 --> 00:11:08,720
species

308
00:11:13,110 --> 00:11:11,200
the apes are much closer and uh to the

309
00:11:15,110 --> 00:11:13,120
base of the tree and they are less

310
00:11:17,269 --> 00:11:15,120
derived more generalized

311
00:11:19,750 --> 00:11:17,279
among other things um the fact that

312
00:11:21,590 --> 00:11:19,760
their limbs can be both used for

313
00:11:24,470 --> 00:11:21,600

as arms or legs

314
00:11:26,550 --> 00:11:24,480
um that they have hands and this is a

315
00:11:27,670 --> 00:11:26,560
fascinating thing i discovered that at

316
00:11:29,110 --> 00:11:27,680
least in english and i haven't

317
00:11:30,389 --> 00:11:29,120
discovered any other language we have a

318
00:11:33,829 --> 00:11:30,399
real problem

319
00:11:38,790 --> 00:11:33,839
with describing what is at the

320
00:11:40,470 --> 00:11:38,800
bottom of a leg attached to a an ape

321
00:11:42,150 --> 00:11:40,480
or a monkey so

322
00:11:45,430 --> 00:11:42,160
they call them feet but they're not

323
00:11:46,949 --> 00:11:45,440
really any different than the hands so

324
00:11:49,110 --> 00:11:46,959
there should be some sort of generalized

325
00:11:51,430 --> 00:11:49,120
terms for those as well

326
00:11:52,870 --> 00:11:51,440
biology apparently has skipped that

327
00:11:53,990 --> 00:11:52,880
particular

328
00:11:55,990 --> 00:11:54,000
thing

329
00:11:57,990 --> 00:11:56,000
going a little bit beyond that axi and

330
00:11:59,670 --> 00:11:58,000
planar symmetry for

331
00:12:01,910 --> 00:11:59,680
this is someone pointed out this is

332
00:12:03,670 --> 00:12:01,920
their favorite phrase of the entire uh

333
00:12:05,910 --> 00:12:03,680
presentation orientation agnostic

334
00:12:07,509 --> 00:12:05,920
functionality so this is a very fancy

335
00:12:09,350 --> 00:12:07,519
way of saying that it doesn't really

336
00:12:11,030 --> 00:12:09,360
matter which way the robot's pointed

337
00:12:12,790 --> 00:12:11,040
what it can do in any particular

338
00:12:14,790 --> 00:12:12,800

direction is the same it can see the

339
00:12:16,710 --> 00:12:14,800
same it can grab the same it can move

340
00:12:18,150 --> 00:12:16,720
the same

341
00:12:19,910 --> 00:12:18,160
and something that goes along with that

342
00:12:21,190 --> 00:12:19,920
a little bit is this hemispherical

343
00:12:23,030 --> 00:12:21,200
coverage

344
00:12:24,710 --> 00:12:23,040
of perception so it can see in any

345
00:12:26,550 --> 00:12:24,720
direction uh

346
00:12:28,230 --> 00:12:26,560
within the hemisphere

347
00:12:29,910 --> 00:12:28,240
so that's sort of the middle bunch and

348
00:12:32,230 --> 00:12:29,920
that's really

349
00:12:34,550 --> 00:12:32,240
the curious george version of it the

350
00:12:36,069 --> 00:12:34,560
other things at the top uh

351
00:12:38,310 --> 00:12:36,079
this is actually going to yet a

352
00:12:41,110 --> 00:12:38,320
different children's story slow is

353
00:12:43,110 --> 00:12:41,120
smooth and smooth is fast so this is

354
00:12:45,110 --> 00:12:43,120
the tortoise and the hair and as a

355
00:12:48,230 --> 00:12:45,120
design philosophy

356
00:12:50,389 --> 00:12:48,240
we picked the tortoise on purpose and it

357
00:12:53,269 --> 00:12:50,399
is not a hair and it doesn't go fast but

358
00:12:54,230 --> 00:12:53,279
it's very sure about what it does

359
00:12:56,310 --> 00:12:54,240
and

360
00:12:58,389 --> 00:12:56,320
because it's sure about what it does it

361
00:13:00,310 --> 00:12:58,399
doesn't make a whole lot of mistakes it

362
00:13:02,790 --> 00:13:00,320
doesn't fall down

363
00:13:04,790 --> 00:13:02,800

and that means that overall

364
00:13:06,870 --> 00:13:04,800
it's faster

365
00:13:09,110 --> 00:13:06,880
and then the final little bit of it is

366
00:13:11,509 --> 00:13:09,120
optimize it towards early deployment so

367
00:13:12,870 --> 00:13:11,519
this is not an academic exercise this is

368
00:13:15,910 --> 00:13:12,880
something that we hope to put in the

369
00:13:18,150 --> 00:13:15,920
field as soon as possible and as such we

370
00:13:21,750 --> 00:13:18,160
needed to keep that in mind uh when we

371
00:13:26,949 --> 00:13:25,430
and so this is what we proposed so when

372
00:13:31,110 --> 00:13:26,959
we told darpa we'd like to build

373
00:13:35,430 --> 00:13:33,670
and it's this near term fieldable system

374
00:13:37,110 --> 00:13:35,440
for disaster response

375
00:13:39,350 --> 00:13:37,120
that's relatively inexpensive to you

376
00:13:42,629 --> 00:13:39,360
know and relatively being the important

377
00:13:44,629 --> 00:13:43,590
and then some of the stuff that we

378
00:13:46,710 --> 00:13:44,639
thought we could do with this kind of

379
00:13:48,389 --> 00:13:46,720
robot this is you know you're seeing the

380
00:13:50,870 --> 00:13:48,399
ladder climbing the driving the vehicle

381
00:13:52,710 --> 00:13:50,880
the opening of the doors

382
00:13:54,710 --> 00:13:52,720
maybe with all of those robots at the

383
00:13:56,230 --> 00:13:54,720
same time would be great

384
00:13:57,990 --> 00:13:56,240
that's kind of where we thought we would

385
00:13:59,670 --> 00:13:58,000
be

386
00:14:02,470 --> 00:13:59,680
and this is where we ended up

387
00:14:03,910 --> 00:14:02,480
so not that different it's got some few

388
00:14:06,550 --> 00:14:03,920

extra little bits

389
00:14:08,310 --> 00:14:06,560
you saw this graphic on the left earlier

390
00:14:10,710 --> 00:14:08,320
i want to point this out in particular

391
00:14:13,189 --> 00:14:10,720
there as a local flavor

392
00:14:15,269 --> 00:14:13,199
this was done by a student of mine noel

393
00:14:16,470 --> 00:14:15,279
ecker who's a at

394
00:14:18,310 --> 00:14:16,480
art institute

395
00:14:19,590 --> 00:14:18,320
and he came and worked with us over the

396
00:14:21,829 --> 00:14:19,600
summer and did some fantastic

397
00:14:22,949 --> 00:14:21,839
illustrations like this

398
00:14:25,030 --> 00:14:22,959
now you can see that there's a little

399
00:14:27,910 --> 00:14:25,040
bit of a difference between the dramatic

400
00:14:30,389 --> 00:14:27,920
representation and what we were actually

401
00:14:30,399 --> 00:14:35,189
but but we do we aspire to that

402
00:14:39,269 --> 00:14:37,750
so we start out with the eminem man

403
00:14:40,629 --> 00:14:39,279
which is what people quickly started

404
00:14:41,430 --> 00:14:40,639
calling it

405
00:14:43,110 --> 00:14:41,440
uh

406
00:14:45,269 --> 00:14:43,120
from there and i will explain a little

407
00:14:47,509 --> 00:14:45,279
bit more of that we moved on to a

408
00:14:49,189 --> 00:14:47,519
concept that was developed here

409
00:14:50,790 --> 00:14:49,199
in conjunction with some of our

410
00:14:53,750 --> 00:14:50,800
industrial designers and artists that

411
00:14:54,790 --> 00:14:53,760
are in residence at jpl

412
00:14:56,550 --> 00:14:54,800
and then

413
00:14:59,750 --> 00:14:56,560

we were able to build that into that

414
00:15:01,590 --> 00:14:59,760
first system for december of 2013

415
00:15:04,230 --> 00:15:01,600
and you can see it's two main poses

416
00:15:06,550 --> 00:15:04,240
whoops the two main poses seated on its

417
00:15:08,949 --> 00:15:06,560
wheels i'll talk about that a little bit

418
00:15:11,910 --> 00:15:08,959
and then the more

419
00:15:15,430 --> 00:15:11,920
uh obvious quadrupedal stance that it

420
00:15:19,269 --> 00:15:17,269
so as i mentioned

421
00:15:21,030 --> 00:15:19,279
we worked with

422
00:15:23,430 --> 00:15:21,040
artists and industrial designers here at

423
00:15:27,110 --> 00:15:23,440
jpl because one of the really important

424
00:15:29,990 --> 00:15:27,120
things i think is that we find a way to

425
00:15:34,310 --> 00:15:30,000
get people to accept the idea of robots

426
00:15:35,910 --> 00:15:34,320
so despite the best technology

427
00:15:38,069 --> 00:15:35,920
as anyone who has picked up different

428
00:15:39,910 --> 00:15:38,079
types of smartphones will know

429
00:15:41,430 --> 00:15:39,920
people like stuff and will pick things

430
00:15:44,150 --> 00:15:41,440
up and use things

431
00:15:44,949 --> 00:15:44,160
for non-rational reasons

432
00:15:47,030 --> 00:15:44,959
so

433
00:15:48,310 --> 00:15:47,040
we need to look at the design of the

434
00:15:49,990 --> 00:15:48,320
robot

435
00:15:52,389 --> 00:15:50,000
now

436
00:15:55,110 --> 00:15:52,399
uh we're a western audience in general i

437
00:15:56,230 --> 00:15:55,120
think in here and western audiences will

438
00:15:58,069 --> 00:15:56,240

give you

439
00:15:59,910 --> 00:15:58,079
generally speaking one of two responses

440
00:16:01,430 --> 00:15:59,920
to robots it's either the terminator or

441
00:16:04,310 --> 00:16:01,440
c-3po

442
00:16:06,230 --> 00:16:04,320
neither of these are good

443
00:16:09,749 --> 00:16:06,240
one is a completely ineffectual system

444
00:16:10,550 --> 00:16:09,759
and the other one is scary

445
00:16:14,710 --> 00:16:10,560
so

446
00:16:16,629 --> 00:16:14,720
and in particular this robot needed to

447
00:16:18,870 --> 00:16:16,639
be able to go into disaster areas and

448
00:16:20,389 --> 00:16:18,880
get used the people that go to disaster

449
00:16:22,629 --> 00:16:20,399
areas are first responders first

450
00:16:24,949 --> 00:16:22,639
responders use tools they use

451
00:16:26,870 --> 00:16:24,959
professional grade tools

452
00:16:29,829 --> 00:16:26,880
what does a professional grade tool look

453
00:16:31,990 --> 00:16:29,839
like when it's a robot and that's what

454
00:16:33,910 --> 00:16:32,000
this system was intended to be in

455
00:16:35,829 --> 00:16:33,920
concept so we spent a lot of time

456
00:16:38,310 --> 00:16:35,839
looking at different

457
00:16:40,069 --> 00:16:38,320
emergency response vehicles we looked at

458
00:16:41,430 --> 00:16:40,079
the uniforms that are worn by first

459
00:16:42,870 --> 00:16:41,440
responders

460
00:16:45,269 --> 00:16:42,880
you can see sort of in the middle there

461
00:16:48,150 --> 00:16:45,279
was a lot of time spent looking at the

462
00:16:50,870 --> 00:16:48,160
way cars are designed

463
00:16:52,790 --> 00:16:50,880

the front of a car is a face

464
00:16:54,230 --> 00:16:52,800
and the expression on that face tells

465
00:16:56,470 --> 00:16:54,240
you a lot about

466
00:16:58,150 --> 00:16:56,480
the type of people that will accept that

467
00:16:59,110 --> 00:16:58,160
particular

468
00:17:00,790 --> 00:16:59,120
car

469
00:17:01,829 --> 00:17:00,800
so very expressive

470
00:17:03,350 --> 00:17:01,839
and so

471
00:17:06,150 --> 00:17:03,360
i think we would like very much to

472
00:17:07,110 --> 00:17:06,160
continue that and and we did our best

473
00:17:09,029 --> 00:17:07,120
now

474
00:17:11,429 --> 00:17:09,039
the practical realities of building a

475
00:17:14,150 --> 00:17:11,439
prototype robot mean that we really

476
00:17:16,789 --> 00:17:14,160
weren't able to to achieve that final

477
00:17:18,870 --> 00:17:16,799
artistic goal uh but we think we did

478
00:17:22,870 --> 00:17:18,880
pretty okay

479
00:17:24,630 --> 00:17:22,880
and and as evidence uh exhibit a was

480
00:17:27,110 --> 00:17:24,640
this little girl

481
00:17:30,150 --> 00:17:27,120
when we went to the trials

482
00:17:31,830 --> 00:17:30,160
she won the photo contest and her prize

483
00:17:34,390 --> 00:17:31,840
was that she could have her photo taken

484
00:17:36,310 --> 00:17:34,400
with any robot she wanted

485
00:17:39,990 --> 00:17:36,320
i'm pretty sure the organizers thought

486
00:17:41,750 --> 00:17:40,000
that robot would be not us

487
00:17:43,430 --> 00:17:41,760
and so but

488
00:17:44,549 --> 00:17:43,440

they came and said she'd really like the

489
00:17:47,350 --> 00:17:44,559
picture with robert simmons can we do

490
00:17:48,230 --> 00:17:47,360
that and sure and and so

491
00:17:52,549 --> 00:17:48,240
uh

492
00:17:54,070 --> 00:17:52,559
to talk to you as well about your

493
00:17:55,510 --> 00:17:54,080
perceptions of what robosimian looks

494
00:17:57,270 --> 00:17:55,520
like but

495
00:18:02,470 --> 00:17:57,280
she thought it was cute

496
00:18:06,710 --> 00:18:04,710
here we go so what does it do and why

497
00:18:08,549 --> 00:18:06,720
does it kind of look like it does and so

498
00:18:10,310 --> 00:18:08,559
moving around we need to be able to walk

499
00:18:12,310 --> 00:18:10,320
this is in the upper left you can see it

500
00:18:14,870 --> 00:18:12,320
walking around this is kind of a neat

501
00:18:16,230 --> 00:18:14,880
graphic this is actually

502
00:18:17,190 --> 00:18:16,240
captured from

503
00:18:22,630 --> 00:18:17,200
a

504
00:18:23,590 --> 00:18:22,640
figuring out how

505
00:18:29,669 --> 00:18:23,600
the

506
00:18:31,750 --> 00:18:29,679
we're using it for a slightly slower

507
00:18:33,590 --> 00:18:31,760
application

508
00:18:34,870 --> 00:18:33,600
and so you see it walking around you can

509
00:18:36,150 --> 00:18:34,880
see there

510
00:18:37,430 --> 00:18:36,160
you can probably just make out the

511
00:18:39,190 --> 00:18:37,440
little red dot that's on the ground

512
00:18:40,549 --> 00:18:39,200
that's its center of gravity you'll

513
00:18:42,310 --> 00:18:40,559

notice that that keeps that center of

514
00:18:44,070 --> 00:18:42,320
gravity within what we call the

515
00:18:45,909 --> 00:18:44,080
stability polygon we'll talk about that

516
00:18:48,950 --> 00:18:45,919
a little bit more but basically it means

517
00:18:50,310 --> 00:18:48,960
this thing is a very stable system

518
00:18:53,750 --> 00:18:50,320
and that's just walking around if you

519
00:18:56,150 --> 00:18:53,760
look in the top middle and the top right

520
00:18:58,390 --> 00:18:56,160
this is the fact that this robot because

521
00:18:59,669 --> 00:18:58,400
it's got hands at the end of every one

522
00:19:01,270 --> 00:18:59,679
of its limbs

523
00:19:04,630 --> 00:19:01,280
can grab onto its environment and

524
00:19:07,669 --> 00:19:04,640
stabilize itself by anchoring and so it

525
00:19:09,430 --> 00:19:07,679
can be on a ladder climbing the ladder

526
00:19:11,430 --> 00:19:09,440
if it can move around

527
00:19:13,430 --> 00:19:11,440
and hold itself there

528
00:19:15,430 --> 00:19:13,440
without any issue so it's not balancing

529
00:19:16,630 --> 00:19:15,440
itself in any way so it's a very stable

530
00:19:19,430 --> 00:19:16,640
and

531
00:19:20,630 --> 00:19:19,440
way of going about things very sure

532
00:19:22,150 --> 00:19:20,640
on the lower left you're seeing what

533
00:19:24,870 --> 00:19:22,160
happens when you start to manipulate the

534
00:19:26,549 --> 00:19:24,880
world so there's just a triple stance

535
00:19:29,110 --> 00:19:26,559
and you can grab stuff and and move

536
00:19:32,870 --> 00:19:31,270
in the lower middle is what happens if

537
00:19:34,870 --> 00:19:32,880
we actually go into a more bipedal

538
00:19:37,029 --> 00:19:34,880

stance now again we're not balancing

539
00:19:39,510 --> 00:19:37,039
here this is actually supporting itself

540
00:19:41,350 --> 00:19:39,520
on a very big piece of

541
00:19:42,390 --> 00:19:41,360
hardware and then manipulating that

542
00:19:44,710 --> 00:19:42,400
hardware

543
00:19:46,390 --> 00:19:44,720
so bimanual operation

544
00:19:48,630 --> 00:19:46,400
and then the lower right is an example

545
00:19:52,150 --> 00:19:48,640
of a valve turn that we're doing from a

546
00:19:56,630 --> 00:19:54,310
now it's got some other aspects to it

547
00:19:58,789 --> 00:19:56,640
one of the really key things is that

548
00:20:00,630 --> 00:19:58,799
like apes it's really about moving

549
00:20:02,470 --> 00:20:00,640
around in a 3d environment this is what

550
00:20:04,230 --> 00:20:02,480
it's really good at it can move across

551
00:20:06,310 --> 00:20:04,240
flat ground but really what it's there

552
00:20:07,750 --> 00:20:06,320
for is to move around in 3d environment

553
00:20:09,510 --> 00:20:07,760
and to the best of my knowledge it is

554
00:20:12,150 --> 00:20:09,520
the only robot that's demonstrated doing

555
00:20:13,830 --> 00:20:12,160
pull-ups i could be wrong but i

556
00:20:15,029 --> 00:20:13,840
i believe that is true

557
00:20:18,310 --> 00:20:15,039
and now you're seeing some of the other

558
00:20:20,390 --> 00:20:18,320
aspects of it the design the dexterity

559
00:20:23,350 --> 00:20:20,400
of the limbs and we'll talk a little bit

560
00:20:26,870 --> 00:20:23,360
more about this in detail but the fact

561
00:20:28,310 --> 00:20:26,880
is that this has the uh same number of

562
00:20:30,549 --> 00:20:28,320
joints

563
00:20:31,750 --> 00:20:30,559

in effect that you do in your arm

564
00:20:33,510 --> 00:20:31,760
however

565
00:20:35,430 --> 00:20:33,520
it is not constrained

566
00:20:37,590 --> 00:20:35,440
when it's doing this

567
00:20:39,909 --> 00:20:37,600
that my arm goes from here to here this

568
00:20:41,990 --> 00:20:39,919
isn't very much range of motion

569
00:20:43,190 --> 00:20:42,000
if i could spin my elbow around 360

570
00:20:44,710 --> 00:20:43,200
degrees that would be more like what

571
00:20:47,750 --> 00:20:44,720
robosimian can do with these limbs and

572
00:20:52,950 --> 00:20:47,760
you're seeing some of that in this video

573
00:20:57,510 --> 00:20:54,870
so that was halfway to the trials and

574
00:21:00,149 --> 00:20:57,520
then here's the trials

575
00:21:03,350 --> 00:21:01,590
as i mentioned

576
00:21:05,830 --> 00:21:03,360
we can move across flat ground by

577
00:21:07,669 --> 00:21:05,840
walking but it's really inefficient

578
00:21:09,270 --> 00:21:07,679
if anybody's ever gotten on a bicycle or

579
00:21:11,029 --> 00:21:09,280
anything else you know that the most

580
00:21:13,029 --> 00:21:11,039
efficient way you can get around and

581
00:21:14,789 --> 00:21:13,039
this is actually you know mathematically

582
00:21:16,870 --> 00:21:14,799
speaking you are about 10 times more

583
00:21:18,149 --> 00:21:16,880
efficient rolling than you are walking

584
00:21:21,430 --> 00:21:18,159
and it doesn't matter how good at

585
00:21:22,950 --> 00:21:21,440
walking you are it just is true right so

586
00:21:24,149 --> 00:21:22,960
about four weeks before the competition

587
00:21:25,990 --> 00:21:24,159
we said you know what we really want to

588
00:21:28,310 --> 00:21:26,000

roll

589
00:21:31,110 --> 00:21:28,320
so we gave it wheels and so it sits down

590
00:21:34,230 --> 00:21:31,120
on its wheels and

591
00:21:37,909 --> 00:21:37,110
and rolls away now do we really think

592
00:21:39,750 --> 00:21:37,919
that

593
00:21:41,750 --> 00:21:39,760
uh real disaster zones are going to give

594
00:21:43,029 --> 00:21:41,760
us nice flat ground to work on

595
00:21:45,669 --> 00:21:43,039
no

596
00:21:47,350 --> 00:21:45,679
but that was the competition that was

597
00:21:49,350 --> 00:21:47,360
what they gave us

598
00:21:51,270 --> 00:21:49,360
so here are some of the other

599
00:21:53,510 --> 00:21:51,280
uh challenges the competition we talked

600
00:21:55,110 --> 00:21:53,520
about here's turning valves

601
00:21:58,070 --> 00:21:55,120
so from our nice seated position we can

602
00:22:06,549 --> 00:21:58,080
use our upper limbs quite easily

603
00:22:13,029 --> 00:22:08,789
and then when we got to get

604
00:22:19,350 --> 00:22:13,039
down to it we can get right on our limbs

605
00:22:22,950 --> 00:22:21,190
the the cinder blocks are actually an

606
00:22:24,870 --> 00:22:22,960
interesting problem because

607
00:22:25,909 --> 00:22:24,880
they are so regular even though they're

608
00:22:27,510 --> 00:22:25,919
supposed to be debris they're very

609
00:22:29,430 --> 00:22:27,520
regular

610
00:22:34,149 --> 00:22:29,440
that in itself actually creates some

611
00:22:34,159 --> 00:22:37,990
that by the way not supposed to happen

612
00:22:41,990 --> 00:22:40,070
but it's an illustration of how stable

613
00:22:43,750 --> 00:22:42,000

this thing is we can make mistakes

614
00:22:45,750 --> 00:22:43,760
without the robot falling over

615
00:22:48,549 --> 00:22:45,760
the we were the only robot to compete

616
00:22:50,470 --> 00:22:48,559
that did not use a safety a physical

617
00:22:52,230 --> 00:22:50,480
safety belay to keep it from rolling

618
00:22:53,750 --> 00:22:52,240
over

619
00:22:55,430 --> 00:22:53,760
and then going back to the doors here we

620
00:22:56,710 --> 00:22:55,440
go

621
00:22:58,870 --> 00:22:56,720
as an added little fun thing about the

622
00:23:01,270 --> 00:22:58,880
doors there was enough wind that uh it

623
00:23:03,029 --> 00:23:01,280
blew the door into the you know after

624
00:23:04,310 --> 00:23:03,039
our opponents had opened the door a lot

625
00:23:05,350 --> 00:23:04,320
of them got the door slammed in their

626
00:23:08,070 --> 00:23:05,360
face

627
00:23:10,630 --> 00:23:08,080
we did not

628
00:23:14,390 --> 00:23:10,640
clearing the debris

629
00:23:18,230 --> 00:23:16,149
notice that there are there's one person

630
00:23:20,630 --> 00:23:18,240
running the robot there's one computer

631
00:23:23,830 --> 00:23:20,640
there's a one monitor

632
00:23:24,950 --> 00:23:23,840
i'll talk about that a little bit

633
00:23:28,710 --> 00:23:24,960
and

634
00:23:35,350 --> 00:23:31,270
just another another fun shot of a

635
00:23:39,909 --> 00:23:35,360
transforming of the mobility modes

636
00:23:43,669 --> 00:23:41,190
okay so

637
00:23:45,750 --> 00:23:43,679
we made it to the competition uh the

638
00:23:48,789 --> 00:23:45,760

field ability aspects of this

639
00:23:50,870 --> 00:23:48,799
it fits in a standard relatively small

640
00:23:53,750 --> 00:23:50,880
box that box goes into a bunch of crates

641
00:23:55,190 --> 00:23:53,760
and so we can basically if and as often

642
00:23:58,149 --> 00:23:55,200
the case

643
00:23:59,590 --> 00:23:58,159
it's a military

644
00:24:01,990 --> 00:23:59,600
mission to go

645
00:24:03,190 --> 00:24:02,000
provide aid in disaster areas we can

646
00:24:05,750 --> 00:24:03,200
load

647
00:24:09,669 --> 00:24:05,760
tens of robots if

648
00:24:11,750 --> 00:24:09,679
not more into a standard cargo vehicle

649
00:24:13,990 --> 00:24:11,760
used by the us military and get these

650
00:24:17,029 --> 00:24:14,000
robots anywhere in the world

651
00:24:18,710 --> 00:24:17,039
in in less than 24 hours

652
00:24:19,830 --> 00:24:18,720
in our particular

653
00:24:21,350 --> 00:24:19,840
um

654
00:24:23,350 --> 00:24:21,360
demonstration of this which was not

655
00:24:24,630 --> 00:24:23,360
necessary but we we take great pride in

656
00:24:27,510 --> 00:24:24,640
it anyway

657
00:24:29,830 --> 00:24:27,520
we shipped uh the robots to florida

658
00:24:32,390 --> 00:24:29,840
which is where the trials were

659
00:24:34,630 --> 00:24:32,400
pulled the robot out of the box and had

660
00:24:35,669 --> 00:24:34,640
it running in 42 minutes

661
00:24:38,710 --> 00:24:35,679
um

662
00:24:40,950 --> 00:24:38,720
i i take great pride in saying and

663
00:24:42,310 --> 00:24:40,960

that some of our opponents

664
00:24:44,149 --> 00:24:42,320
well it probably took them the better

665
00:24:45,510 --> 00:24:44,159
part of 24 hours to get their robots up

666
00:24:46,390 --> 00:24:45,520
and running

667
00:24:48,549 --> 00:24:46,400
so

668
00:24:50,149 --> 00:24:48,559
this is this told me that we were doing

669
00:24:51,830 --> 00:24:50,159
a lot of the right stuff

670
00:24:53,830 --> 00:24:51,840
the other thing is that you'll notice in

671
00:24:56,789 --> 00:24:53,840
the bottom picture this is again the

672
00:24:58,549 --> 00:24:56,799
setup there's a robot there's a person

673
00:25:01,110 --> 00:24:58,559
in a folding chair there are a couple

674
00:25:03,430 --> 00:25:01,120
people just to keep them company and two

675
00:25:04,630 --> 00:25:03,440
monitors in the computer that's it you

676
00:25:06,630 --> 00:25:04,640
know this is what it takes to run the

677
00:25:09,110 --> 00:25:06,640
robot

678
00:25:10,950 --> 00:25:09,120
it was so empty inside this is done at a

679
00:25:12,390 --> 00:25:10,960
nascar track it was so empty inside of

680
00:25:13,990 --> 00:25:12,400
our garage that people walk through

681
00:25:15,029 --> 00:25:14,000
there and we're about halfway through

682
00:25:16,630 --> 00:25:15,039
before they realized that they were

683
00:25:19,750 --> 00:25:16,640
walking through our garage they thought

684
00:25:22,630 --> 00:25:19,760
it was just an empty empty space

685
00:25:24,710 --> 00:25:22,640
other teams filled and i do mean filled

686
00:25:27,590 --> 00:25:24,720
their garages with computers and

687
00:25:28,630 --> 00:25:27,600
monitors and and people and stuff

688
00:25:31,110 --> 00:25:28,640

and

689
00:25:33,510 --> 00:25:31,120
so again told me that we were doing what

690
00:25:35,190 --> 00:25:33,520
i felt to be the right thing

691
00:25:37,510 --> 00:25:35,200
so talking about those limbs so seven

692
00:25:40,230 --> 00:25:37,520
joints so you it'll teach you a little

693
00:25:42,149 --> 00:25:40,240
robotics and if anybody came to the talk

694
00:25:44,070 --> 00:25:42,159
a couple of years ago you might remember

695
00:25:45,110 --> 00:25:44,080
this version of it but

696
00:25:47,430 --> 00:25:45,120
you've got

697
00:25:48,870 --> 00:25:47,440
seven joints you just don't seem to you

698
00:25:50,549 --> 00:25:48,880
normally count it you say

699
00:25:53,350 --> 00:25:50,559
one two three

700
00:25:54,630 --> 00:25:53,360
but for a roboticist you actually have

701
00:25:56,950 --> 00:25:54,640
three because you can get three

702
00:25:59,029 --> 00:25:56,960
rotations out of your shoulder you have

703
00:26:00,549 --> 00:25:59,039
another one at your elbow and another

704
00:26:04,310 --> 00:26:00,559
three at your wrist

705
00:26:07,110 --> 00:26:04,320
so those three effective joints that you

706
00:26:08,870 --> 00:26:07,120
have are translated into this design as

707
00:26:12,789 --> 00:26:08,880
discrete

708
00:26:13,750 --> 00:26:12,799
chunks

709
00:26:15,430 --> 00:26:13,760
so

710
00:26:17,830 --> 00:26:15,440
um again

711
00:26:20,470 --> 00:26:17,840
it can do basically everything that you

712
00:26:22,710 --> 00:26:20,480
can but has all of this extra rotation

713
00:26:24,710 --> 00:26:22,720

allow us to do things like fold the

714
00:26:26,070 --> 00:26:24,720
arm up in their limb up into that nice

715
00:26:27,510 --> 00:26:26,080
little package

716
00:26:29,029 --> 00:26:27,520
um

717
00:26:31,110 --> 00:26:29,039
so and we'll talk a little bit about

718
00:26:32,070 --> 00:26:31,120
this the single actuator design in a

719
00:26:35,110 --> 00:26:32,080
second

720
00:26:37,590 --> 00:26:35,120
it it's about human scale reach

721
00:26:40,149 --> 00:26:37,600
um it's a lot heavier than your arm

722
00:26:42,470 --> 00:26:40,159
because metal isn't nearly as nice as

723
00:26:45,430 --> 00:26:42,480
bone these days

724
00:26:47,510 --> 00:26:45,440
and then it's strong so if you can

725
00:26:49,269 --> 00:26:47,520
imagine taking i don't know if anybody's

726
00:26:51,190 --> 00:26:49,279
got a first grader in here but taking

727
00:26:53,350 --> 00:26:51,200
your first grader and doing this

728
00:26:54,710 --> 00:26:53,360
and basically this robot could do this

729
00:26:57,269 --> 00:26:54,720
infinitely

730
00:27:00,470 --> 00:26:57,279
with a first grader

731
00:27:03,830 --> 00:27:00,480
it'll do a seventh grader once and then

732
00:27:06,470 --> 00:27:03,840
have to cool off and then do it again

733
00:27:07,830 --> 00:27:06,480
but still i mean can if you can imagine

734
00:27:10,070 --> 00:27:07,840
a human

735
00:27:11,029 --> 00:27:10,080
curling a seventh grader with one arm

736
00:27:13,669 --> 00:27:11,039
and

737
00:27:15,590 --> 00:27:13,679
any seventh graders in the audience yeah

738
00:27:17,669 --> 00:27:15,600

there you go so just imagine yourself

739
00:27:19,990 --> 00:27:17,679
being picked up by nicely picked up by

740
00:27:22,230 --> 00:27:20,000
the robot

741
00:27:24,310 --> 00:27:22,240
it moves so two meters a second two

742
00:27:25,830 --> 00:27:24,320
meters a second is about

743
00:27:28,710 --> 00:27:25,840
five and a half miles an hour it doesn't

744
00:27:30,230 --> 00:27:28,720
sound super fast but if you're just

745
00:27:32,470 --> 00:27:30,240
if you're just moving yourself around

746
00:27:34,230 --> 00:27:32,480
this is actually pretty quick

747
00:27:36,310 --> 00:27:34,240
and it's really quick if it's a robot

748
00:27:37,590 --> 00:27:36,320
and you're you know standing close

749
00:27:39,430 --> 00:27:37,600
enough to it that you're a little

750
00:27:41,029 --> 00:27:39,440
surprised by how fast that goes the

751
00:27:42,310 --> 00:27:41,039
other aspect of that is there's very

752
00:27:44,470 --> 00:27:42,320
little that we want to do with this

753
00:27:46,070 --> 00:27:44,480
robot that needs to go faster than that

754
00:27:48,149 --> 00:27:46,080
that's kind of analogous to how slower

755
00:27:50,230 --> 00:27:48,159
mars rovers go you know we can make our

756
00:27:52,710 --> 00:27:50,240
mars rover go faster but we don't

757
00:27:53,430 --> 00:27:52,720
actually want to get anywhere faster and

758
00:27:55,750 --> 00:27:53,440
so

759
00:27:58,549 --> 00:27:55,760
giving it all the added capability um in

760
00:28:00,630 --> 00:27:58,559
terms of of its mobility at the price of

761
00:28:02,470 --> 00:28:00,640
speed is just okay because it's not in

762
00:28:04,549 --> 00:28:02,480
in the requirement list i'm sure it

763
00:28:07,029 --> 00:28:04,559

would be neater to make the movie if

764
00:28:08,230 --> 00:28:07,039
this thing went faster but it's just not

765
00:28:11,190 --> 00:28:08,240
not the thing that we're really

766
00:28:13,110 --> 00:28:11,200
concentrating all the time

767
00:28:14,630 --> 00:28:13,120
so that's the single actuator

768
00:28:18,070 --> 00:28:14,640
so just to give you a little scale on

769
00:28:21,190 --> 00:28:18,080
this all right so this

770
00:28:23,029 --> 00:28:21,200
is ev inside every joint

771
00:28:25,830 --> 00:28:23,039
there's one

772
00:28:29,269 --> 00:28:25,840
type of drivetrain so all 28 joints in

773
00:28:30,950 --> 00:28:29,279
the robot have one of these inside

774
00:28:33,110 --> 00:28:30,960
that's for

775
00:28:34,630 --> 00:28:33,120
a few good reasons now if you think

776
00:28:37,269 --> 00:28:34,640
again about yourself you've got

777
00:28:39,190 --> 00:28:37,279
relatively robust joints here

778
00:28:41,029 --> 00:28:39,200
uh and and muscles that run them your

779
00:28:43,750 --> 00:28:41,039
elbow a little less so and then out

780
00:28:45,590 --> 00:28:43,760
towards the wrist so you actually get

781
00:28:48,149 --> 00:28:45,600
progressively smaller as you go out

782
00:28:50,389 --> 00:28:48,159
towards the end uh rose semi doesn't do

783
00:28:51,830 --> 00:28:50,399
that it's robust from one end to the

784
00:28:53,830 --> 00:28:51,840
other

785
00:28:55,510 --> 00:28:53,840
first reason for that is that making a

786
00:28:57,350 --> 00:28:55,520
bunch of these is a lot less expensive

787
00:29:00,630 --> 00:28:57,360
than making a bunch of a bunch of other

788
00:29:02,149 --> 00:29:00,640

things so commonality of all these these

789
00:29:05,269 --> 00:29:02,159
parts

790
00:29:06,710 --> 00:29:05,279
the second big reason is that if you're

791
00:29:09,029 --> 00:29:06,720
going out into the field and you need to

792
00:29:11,269 --> 00:29:09,039
take spares you take a few of these

793
00:29:14,070 --> 00:29:11,279
instead of a bunch of other things

794
00:29:16,470 --> 00:29:14,080
and the last reason is as it turns out

795
00:29:19,750 --> 00:29:16,480
if you are

796
00:29:21,190 --> 00:29:19,760
going out and grabbing onto things and

797
00:29:22,789 --> 00:29:21,200
yanking them around and doing all these

798
00:29:24,470 --> 00:29:22,799
other things

799
00:29:26,470 --> 00:29:24,480
when once you grab onto something it

800
00:29:28,470 --> 00:29:26,480
doesn't really matter if it's attached

801
00:29:30,549 --> 00:29:28,480
to much my shoulder or it's attached to

802
00:29:32,389 --> 00:29:30,559
my wrist you actually need basically the

803
00:29:33,830 --> 00:29:32,399
same capabilities and this is why people

804
00:29:35,669 --> 00:29:33,840
break their wrists

805
00:29:36,789 --> 00:29:35,679
right you can actually people are

806
00:29:38,310 --> 00:29:36,799
actually really great at hurting

807
00:29:41,350 --> 00:29:38,320
themselves they're also really good at

808
00:29:42,630 --> 00:29:41,360
healing which is one thing we can't do

809
00:29:45,269 --> 00:29:42,640
so

810
00:29:46,630 --> 00:29:45,279
we it actually works out to be a very

811
00:29:49,830 --> 00:29:46,640
convenient thing to have all the same

812
00:29:52,070 --> 00:29:49,840
joints for that that reason

813
00:29:52,950 --> 00:29:52,080

so some other fun little superlatives

814
00:29:56,950 --> 00:29:52,960
from this

815
00:29:58,630 --> 00:29:56,960
is that that joint while very slow

816
00:30:00,950 --> 00:29:58,640
still produces the same amount of torque

817
00:30:02,870 --> 00:30:00,960
as an f-150 truck

818
00:30:04,310 --> 00:30:02,880
so now it's a big difference if you've

819
00:30:05,830 --> 00:30:04,320
got wheels that are that big and you got

820
00:30:08,870 --> 00:30:05,840
a tow big trailer and a bunch of other

821
00:30:10,710 --> 00:30:08,880
things but basically and plus it can

822
00:30:13,110 --> 00:30:10,720
generate that much torque at 50 miles an

823
00:30:17,350 --> 00:30:13,120
hour and details

824
00:30:19,110 --> 00:30:17,360
regardless that's a lot of pulling power

825
00:30:21,190 --> 00:30:19,120
and so if we're trying to lift ourselves

826
00:30:24,149 --> 00:30:21,200
it's a heavy robot it's about the same

827
00:30:26,470 --> 00:30:24,159
weight as a as a large man

828
00:30:28,789 --> 00:30:26,480
that uh we can do

829
00:30:30,870 --> 00:30:28,799
real things in the real world

830
00:30:32,950 --> 00:30:30,880
um and then sort of these mechanical

831
00:30:34,710 --> 00:30:32,960
power numbers you know think about the

832
00:30:36,470 --> 00:30:34,720
number of lights that you can do with

833
00:30:38,230 --> 00:30:36,480
that

834
00:30:42,789 --> 00:30:38,240
it turns out not to be a good comparison

835
00:30:46,710 --> 00:30:44,950
all right now at the end of all these

836
00:30:47,510 --> 00:30:46,720
limbs there's a hand

837
00:30:48,549 --> 00:30:47,520
so

838
00:30:50,230 --> 00:30:48,559

when

839
00:30:51,110 --> 00:30:50,240
we did the proposal the hand and the

840
00:30:54,630 --> 00:30:51,120
left

841
00:30:56,870 --> 00:30:54,640
uh is what we worked with uh stanford

842
00:30:57,990 --> 00:30:56,880
university on it's a very nifty looking

843
00:31:00,630 --> 00:30:58,000
hand

844
00:31:02,149 --> 00:31:00,640
it looks really good in a proposal

845
00:31:03,190 --> 00:31:02,159
then you got to make one

846
00:31:05,669 --> 00:31:03,200
so

847
00:31:07,590 --> 00:31:05,679
we worked with the grad student stanford

848
00:31:09,750 --> 00:31:07,600
and i told them

849
00:31:11,110 --> 00:31:09,760
okay well we know that we want to really

850
00:31:13,269 --> 00:31:11,120
interact in a forceful way with the

851
00:31:15,669 --> 00:31:13,279
world and we never want to worry too

852
00:31:17,669 --> 00:31:15,679
much about how big a thing we can grab

853
00:31:19,669 --> 00:31:17,679
go find out how big wilt chamberlain's

854
00:31:21,909 --> 00:31:19,679
hand is and make me a hand that's the

855
00:31:23,669 --> 00:31:21,919
same size as wilt chamberlain's hand

856
00:31:24,789 --> 00:31:23,679
so he did and there's nothing in the

857
00:31:26,789 --> 00:31:24,799
scale

858
00:31:28,310 --> 00:31:26,799
from that picture but i will tell you

859
00:31:29,430 --> 00:31:28,320
that it's a really bad idea to make

860
00:31:33,830 --> 00:31:29,440
something as big as wilt chamberlain's

861
00:31:35,350 --> 00:31:33,840
hand because it was a really big hand

862
00:31:36,630 --> 00:31:35,360
and it turned out because it was very

863
00:31:38,630 --> 00:31:36,640

funny because he showed up and he's like

864
00:31:40,630 --> 00:31:38,640
here it is and it's like that thing's

865
00:31:43,430 --> 00:31:40,640
gigantic it can't grab anything

866
00:31:46,549 --> 00:31:43,440
so grabbing grabbing door handles

867
00:31:47,830 --> 00:31:46,559
grabbing drills it was just too big

868
00:31:49,029 --> 00:31:47,840
so i don't know how well chamberlain you

869
00:31:50,630 --> 00:31:49,039
know did any work on his house i'm

870
00:31:52,870 --> 00:31:50,640
guessing it was good that he

871
00:31:53,750 --> 00:31:52,880
you know probably had somebody for that

872
00:31:56,149 --> 00:31:53,760
so

873
00:31:57,509 --> 00:31:56,159
we backed off of wilt chamberlain and

874
00:31:59,990 --> 00:31:57,519
got down to

875
00:32:02,310 --> 00:32:00,000
the hand that you see in the upper right

876
00:32:04,149 --> 00:32:02,320
so this is basically a human scale hand

877
00:32:05,430 --> 00:32:04,159
it's got articulated fingers we call

878
00:32:07,350 --> 00:32:05,440
them under actuated which means that

879
00:32:10,389 --> 00:32:07,360
there's just basically one motor that

880
00:32:11,750 --> 00:32:10,399
pulls on tendons very similar to your

881
00:32:14,789 --> 00:32:11,760
own fingers

882
00:32:16,710 --> 00:32:14,799
and those tendons then cause the finger

883
00:32:18,230 --> 00:32:16,720
to rotate and if they encounter

884
00:32:20,549 --> 00:32:18,240
something they wrap around it so that's

885
00:32:22,789 --> 00:32:20,559
an under-actuated finger because instead

886
00:32:24,549 --> 00:32:22,799
of all the muscles that we have

887
00:32:26,950 --> 00:32:24,559
it has one

888
00:32:29,029 --> 00:32:26,960

motor that runs all of those tendons

889
00:32:30,389 --> 00:32:29,039
and you can see it does you know the job

890
00:32:31,990 --> 00:32:30,399
pretty well

891
00:32:33,029 --> 00:32:32,000
but it was

892
00:32:34,230 --> 00:32:33,039
weak

893
00:32:35,990 --> 00:32:34,240
and

894
00:32:37,750 --> 00:32:36,000
interestingly enough

895
00:32:39,269 --> 00:32:37,760
it breaks exactly the same way that

896
00:32:40,870 --> 00:32:39,279
people's hands do so

897
00:32:43,110 --> 00:32:40,880
i myself

898
00:32:45,750 --> 00:32:43,120
and uh you probably can't see from there

899
00:32:47,750 --> 00:32:45,760
this is called jersey finger

900
00:32:49,669 --> 00:32:47,760
and so if anybody's thinking about

901
00:32:51,190 --> 00:32:49,679
playing football and they're of high

902
00:32:53,430 --> 00:32:51,200
school age i'll

903
00:32:54,789 --> 00:32:53,440
do my little cautionary tale tonight

904
00:32:56,549 --> 00:32:54,799
so jersey finger it's called jersey

905
00:32:57,750 --> 00:32:56,559
finger because if you grab somebody's

906
00:32:59,830 --> 00:32:57,760
jersey

907
00:33:02,230 --> 00:32:59,840
and they yank it

908
00:33:03,430 --> 00:33:02,240
the tendons in your fingers tend to

909
00:33:05,509 --> 00:33:03,440
break

910
00:33:08,070 --> 00:33:05,519
in something called an avulsion fracture

911
00:33:11,669 --> 00:33:10,149
it's a problem

912
00:33:13,830 --> 00:33:11,679
and as it turned out as a problem for us

913
00:33:16,070 --> 00:33:13,840

too in the competition we broke one

914
00:33:17,990 --> 00:33:16,080
finger per door

915
00:33:20,070 --> 00:33:18,000
fortunately we had three fingers and

916
00:33:21,830 --> 00:33:20,080
three doors

917
00:33:25,350 --> 00:33:21,840
and they allowed us to fix the fingers

918
00:33:26,630 --> 00:33:25,360
between between runs so

919
00:33:28,470 --> 00:33:26,640
this is not

920
00:33:30,630 --> 00:33:28,480
optimal

921
00:33:33,509 --> 00:33:30,640
and the fact of the matter is people

922
00:33:34,789 --> 00:33:33,519
hurt their hands doing robust work all

923
00:33:37,269 --> 00:33:34,799
the time

924
00:33:39,830 --> 00:33:37,279
they heal well robots don't

925
00:33:41,430 --> 00:33:39,840
and so that seemed like the wrong

926
00:33:43,029 --> 00:33:41,440
way to go forward

927
00:33:45,190 --> 00:33:43,039
so what might be the and of course the

928
00:33:47,029 --> 00:33:45,200
other fun aspect of all of this is that

929
00:33:48,630 --> 00:33:47,039
because we walk around on our hands they

930
00:33:50,149 --> 00:33:48,640
actually have to be able to do that and

931
00:33:52,470 --> 00:33:50,159
so you notice that the fingers actually

932
00:33:55,669 --> 00:33:52,480
fold back on themselves that wasn't such

933
00:33:58,470 --> 00:33:55,679
a it worked but it wasn't super duper

934
00:33:59,990 --> 00:33:58,480
so we went back and

935
00:34:02,549 --> 00:34:00,000
you'll see the progression here of

936
00:34:04,870 --> 00:34:02,559
something that we call the cam hand

937
00:34:07,269 --> 00:34:04,880
the cam hand is basically supposed to be

938
00:34:09,829 --> 00:34:07,279

able to do what you could do in a heavy

939
00:34:10,790 --> 00:34:09,839
work glove which is in line with the

940
00:34:12,470 --> 00:34:10,800
type of

941
00:34:15,190 --> 00:34:12,480
jobs that we expect from this thing in a

942
00:34:18,310 --> 00:34:15,200
disaster scenario so starts from yes

943
00:34:20,310 --> 00:34:18,320
people really do sketch things on paper

944
00:34:21,750 --> 00:34:20,320
and then we went and we made ourselves

945
00:34:23,990 --> 00:34:21,760
and i know it's a little tough to make

946
00:34:27,109 --> 00:34:24,000
out because we we used clear

947
00:34:29,669 --> 00:34:27,119
plastic to to do it but uh we prototyped

948
00:34:31,270 --> 00:34:29,679
this thing and basically the thing you

949
00:34:33,030 --> 00:34:31,280
see in the middle is something that we

950
00:34:33,750 --> 00:34:33,040
walked around with and we grabbed stuff

951
00:34:35,909 --> 00:34:33,760
with

952
00:34:37,750 --> 00:34:35,919
so little puppeteering

953
00:34:41,510 --> 00:34:37,760
and based on that we felt good enough

954
00:34:44,710 --> 00:34:43,349
the actual hand

955
00:34:50,710 --> 00:34:44,720
so

956
00:34:58,470 --> 00:34:53,589
it's very slow

957
00:35:01,670 --> 00:35:00,069
so here's the cam hand

958
00:35:04,230 --> 00:35:01,680
now to the best of my knowledge again

959
00:35:07,109 --> 00:35:04,240
there is no other system like this

960
00:35:10,470 --> 00:35:09,030
so what you're seeing is that basically

961
00:35:12,230 --> 00:35:10,480
a simple

962
00:35:14,710 --> 00:35:12,240
what might be called a pinch grasp

963
00:35:18,150 --> 00:35:17,030

in that way not much different than

964
00:35:19,750 --> 00:35:18,160
other hands that have been built over

965
00:35:22,390 --> 00:35:19,760
the years very simple ones

966
00:35:23,349 --> 00:35:22,400
but it has some particular features

967
00:35:24,950 --> 00:35:23,359
so you're seeing that it can

968
00:35:27,670 --> 00:35:24,960
individually

969
00:35:28,950 --> 00:35:27,680
move one set of the fingers

970
00:35:31,270 --> 00:35:28,960
the other set of fingers are actually

971
00:35:32,950 --> 00:35:31,280
slaved together so

972
00:35:35,510 --> 00:35:32,960
two on one side are slave together and

973
00:35:37,349 --> 00:35:35,520
then two on the other are independent

974
00:35:39,430 --> 00:35:37,359
i'll explain that a little more i do

975
00:35:41,510 --> 00:35:39,440
believe outside of iron giant the movie

976
00:35:45,750 --> 00:35:41,520
this is the only self-ambulatory hand

977
00:35:48,150 --> 00:35:46,950
and you're seeing one of the other

978
00:35:49,910 --> 00:35:48,160
really important aspects about it is

979
00:35:51,670 --> 00:35:49,920
that all of those fingers can just like

980
00:35:52,630 --> 00:35:51,680
the limbs they can all rotate all the

981
00:35:53,670 --> 00:35:52,640
way around

982
00:35:55,910 --> 00:35:53,680
so

983
00:35:57,349 --> 00:35:55,920
starting off we need a foot now not only

984
00:35:58,550 --> 00:35:57,359
is it a foot but it's a foot that can be

985
00:36:00,710 --> 00:35:58,560
configured in a lot of different ways

986
00:36:03,109 --> 00:36:00,720
it's nice rolling foot so we've got a

987
00:36:04,950 --> 00:36:03,119
nice rolling contact

988
00:36:06,470 --> 00:36:04,960

and a clawed foot

989
00:36:08,310 --> 00:36:06,480
and on top of that if you run the

990
00:36:11,430 --> 00:36:08,320
fingers in the same direction at the

991
00:36:12,390 --> 00:36:11,440
same time we actually get yet another

992
00:36:14,470 --> 00:36:12,400
degree

993
00:36:16,470 --> 00:36:14,480
of freedom out of this so a wrist and

994
00:36:18,470 --> 00:36:16,480
ankle

995
00:36:20,470 --> 00:36:18,480
now it's got some oomph so here's our

996
00:36:24,069 --> 00:36:20,480
standard 4x4

997
00:36:29,109 --> 00:36:25,430
and we've gone through the commercial

998
00:36:41,990 --> 00:36:29,119
hands there you can't do this with those

999
00:36:46,150 --> 00:36:43,829
and there is no other hand in the entire

1000
00:36:47,430 --> 00:36:46,160
world that does this at all so anybody

1001
00:36:49,109 --> 00:36:47,440
who climbs

1002
00:36:50,710 --> 00:36:49,119
uh for fun

1003
00:36:53,670 --> 00:36:50,720
um and i know there's some people out

1004
00:36:55,430 --> 00:36:53,680
there that do this this is called a cam

1005
00:36:57,829 --> 00:36:55,440
cams are what are called self-locking

1006
00:36:59,510 --> 00:36:57,839
mechanisms and are great for negative

1007
00:37:04,069 --> 00:36:59,520
space grips

1008
00:37:04,079 --> 00:37:09,030
remember these robots are here to help

1009
00:37:12,150 --> 00:37:10,790
so not much different actually than the

1010
00:37:15,270 --> 00:37:12,160
fire department showing up with the jaws

1011
00:37:18,630 --> 00:37:17,430
now we'll use this hand in various ways

1012
00:37:19,910 --> 00:37:18,640
so here's

1013
00:37:21,030 --> 00:37:19,920

the vehicle that we need to drive so

1014
00:37:22,550 --> 00:37:21,040
we're actually going to grab it right in

1015
00:37:25,510 --> 00:37:22,560
the middle we've got a nice joint that

1016
00:37:27,190 --> 00:37:25,520
rotates 360 degrees plus right

1017
00:37:29,190 --> 00:37:27,200
and we got to we're going to grab the

1018
00:37:30,950 --> 00:37:29,200
roll cage to get ourselves out of the

1019
00:37:31,750 --> 00:37:30,960
vehicle

1020
00:37:33,750 --> 00:37:31,760
so

1021
00:37:35,990 --> 00:37:33,760
very robust

1022
00:37:38,230 --> 00:37:36,000
but at the same time this is actually a

1023
00:37:40,950 --> 00:37:38,240
really hard thing to do push a button

1024
00:37:42,550 --> 00:37:40,960
with most of the commercial hands

1025
00:37:47,670 --> 00:37:42,560
and at the same time we have to respect

1026
00:37:49,510 --> 00:37:47,680
the aspect ratio of a human hand

1027
00:37:50,950 --> 00:37:49,520
and keep it so that it can actually use

1028
00:37:55,990 --> 00:37:50,960
human tools

1029
00:37:59,349 --> 00:37:57,430
now there are two tricks to using the

1030
00:38:00,950 --> 00:37:59,359
drill as i mentioned one is being able

1031
00:38:02,710 --> 00:38:00,960
to grab the thing in the first place

1032
00:38:03,510 --> 00:38:02,720
actually i guess they're three grab the

1033
00:38:06,069 --> 00:38:03,520
thing

1034
00:38:09,349 --> 00:38:06,079
turn the trigger

1035
00:38:14,630 --> 00:38:11,270
and then the last and most important

1036
00:38:16,470 --> 00:38:14,640
thing is you can actually hold on to it

1037
00:38:19,670 --> 00:38:16,480
in a stable way such that you can

1038
00:38:21,270 --> 00:38:19,680

actually do real work with it

1039
00:38:23,510 --> 00:38:21,280
so this is the task we got to cut a hole

1040
00:38:25,430 --> 00:38:23,520
in a wall as you might remember

1041
00:38:27,109 --> 00:38:25,440
so that is a drywall bit that you saw on

1042
00:38:29,510 --> 00:38:27,119
the drill

1043
00:38:32,630 --> 00:38:29,520
and this is the robot holding on

1044
00:38:32,640 --> 00:38:35,990
enough to cut that hole

1045
00:38:38,630 --> 00:38:36,950
so

1046
00:38:39,829 --> 00:38:38,640
here i have just for scale you can see

1047
00:38:41,829 --> 00:38:39,839
this thing

1048
00:38:43,829 --> 00:38:41,839
you know it's about

1049
00:38:45,349 --> 00:38:43,839
a little bit wider than i am

1050
00:38:47,349 --> 00:38:45,359
this

1051
00:38:48,790 --> 00:38:47,359
hand actually has a capacity every

1052
00:38:51,510 --> 00:38:48,800
finger of it can hold up the entire

1053
00:38:52,230 --> 00:38:51,520
weight of the robot

1054
00:38:55,750 --> 00:38:52,240
so

1055
00:38:57,910 --> 00:38:55,760
us a lot of capacity there

1056
00:38:59,190 --> 00:38:57,920
again not fast and just like the joints

1057
00:39:02,390 --> 00:38:59,200
of the

1058
00:39:04,230 --> 00:39:02,400
limb produces about the same amount of

1059
00:39:05,270 --> 00:39:04,240
torque as that f-150 we were talking

1060
00:39:07,109 --> 00:39:05,280
about earlier

1061
00:39:08,630 --> 00:39:07,119
so

1062
00:39:10,390 --> 00:39:08,640
we have we haven't really experimented

1063
00:39:11,910 --> 00:39:10,400

it too much

1064
00:39:13,670 --> 00:39:11,920
one over

1065
00:39:16,150 --> 00:39:13,680
the child of of one of our own here at

1066
00:39:18,310 --> 00:39:16,160
jpl uh fletcher

1067
00:39:20,150 --> 00:39:18,320
did as a high school student designed

1068
00:39:22,310 --> 00:39:20,160
the fingers that are on here we haven't

1069
00:39:23,109 --> 00:39:22,320
seen any reason whatsoever to change

1070
00:39:26,470 --> 00:39:23,119
them

1071
00:39:27,910 --> 00:39:26,480
turns out to be a it's by design a very

1072
00:39:29,589 --> 00:39:27,920
easy thing to do so we can pop these

1073
00:39:32,310 --> 00:39:29,599
things off substitute in a different

1074
00:39:33,750 --> 00:39:32,320
design if we so chose like for instance

1075
00:39:36,069 --> 00:39:33,760
you know since these things passed by

1076
00:39:37,109 --> 00:39:36,079
each other they make really great

1077
00:39:39,109 --> 00:39:37,119
clippers

1078
00:39:40,470 --> 00:39:39,119
and so building a wire clipping

1079
00:39:42,790 --> 00:39:40,480
capability of these systems would be

1080
00:39:44,790 --> 00:39:42,800
really easy or other things that would

1081
00:39:47,430 --> 00:39:44,800
come along with sort of the cam aspects

1082
00:39:54,790 --> 00:39:47,440
of it so just give you an idea this is

1083
00:39:59,750 --> 00:39:57,589
now i'm going to take a big turn here

1084
00:40:01,430 --> 00:39:59,760
now and i'm going to do it because i

1085
00:40:02,710 --> 00:40:01,440
want to talk about software but to talk

1086
00:40:04,550 --> 00:40:02,720
about some software i actually have to

1087
00:40:06,550 --> 00:40:04,560
talk about this other robot first so

1088
00:40:09,990 --> 00:40:06,560

this other robot

1089
00:40:11,910 --> 00:40:10,000
is a product of robo-simian technology

1090
00:40:14,030 --> 00:40:11,920
those limbs and all of the philosophies

1091
00:40:16,710 --> 00:40:14,040
behind them can be

1092
00:40:19,910 --> 00:40:16,720
re-constituted into a different robot

1093
00:40:23,190 --> 00:40:21,270
so surrogate

1094
00:40:25,510 --> 00:40:23,200
was actually done for a different agency

1095
00:40:28,470 --> 00:40:25,520
not darpa in this case it's actually for

1096
00:40:30,310 --> 00:40:28,480
something called ditra now be honest how

1097
00:40:31,910 --> 00:40:30,320
many people in this room know what ditra

1098
00:40:35,190 --> 00:40:31,920
is

1099
00:40:37,109 --> 00:40:35,200
okay i've got one person in the booth

1100
00:40:39,829 --> 00:40:37,119
all right it's the defense threat

1101
00:40:41,510 --> 00:40:39,839
reduction agency so now how many people

1102
00:40:43,190 --> 00:40:41,520
in the room know what it is

1103
00:40:45,910 --> 00:40:43,200
okay

1104
00:40:47,990 --> 00:40:45,920
um so they're the people who are going

1105
00:40:49,990 --> 00:40:48,000
to show up at your doorstep if you have

1106
00:40:53,829 --> 00:40:50,000
an anthrax scare

1107
00:40:56,550 --> 00:40:53,839
or a radiological problem

1108
00:40:58,710 --> 00:40:56,560
um or things of that nature

1109
00:40:59,589 --> 00:40:58,720
and they're here to help

1110
00:41:01,510 --> 00:40:59,599
and

1111
00:41:02,950 --> 00:41:01,520
uh to get into that hazardous

1112
00:41:04,309 --> 00:41:02,960
environment they need to deal with it's

1113
00:41:06,710 --> 00:41:04,319

not necessarily environment that

1114
00:41:09,270 --> 00:41:06,720
actually is in a degraded condition it

1115
00:41:11,990 --> 00:41:09,280
just has something nasty in it so to

1116
00:41:14,309 --> 00:41:12,000
move more quickly we picked a tracked

1117
00:41:16,069 --> 00:41:14,319
base and then to do these probably more

1118
00:41:19,109 --> 00:41:16,079
sophisticated manipulation

1119
00:41:21,030 --> 00:41:19,119
tasks we gave it arms now so these are

1120
00:41:22,710 --> 00:41:21,040
the same limbs that we talked about

1121
00:41:24,710 --> 00:41:22,720
before but really now they're just being

1122
00:41:26,630 --> 00:41:24,720
used as arms

1123
00:41:27,910 --> 00:41:26,640
with some caveats

1124
00:41:30,470 --> 00:41:27,920
and

1125
00:41:31,750 --> 00:41:30,480
a spine so this is another unique

1126
00:41:32,950 --> 00:41:31,760
feature

1127
00:41:35,109 --> 00:41:32,960
not to be found in other robots there's

1128
00:41:38,150 --> 00:41:35,119
an articulated spine

1129
00:41:39,829 --> 00:41:38,160
that can move around in more degrees of

1130
00:41:41,670 --> 00:41:39,839
freedom because it's the same thing it's

1131
00:41:43,270 --> 00:41:41,680
the same limb those seven degrees of

1132
00:41:44,710 --> 00:41:43,280
freedom

1133
00:41:46,390 --> 00:41:44,720
so that it can do things that other

1134
00:41:47,670 --> 00:41:46,400
robots cannot

1135
00:41:49,349 --> 00:41:47,680
and then finally we actually gave it in

1136
00:41:51,750 --> 00:41:49,359
this case a head

1137
00:41:53,430 --> 00:41:51,760
that has cameras and this lidar on top

1138
00:41:55,430 --> 00:41:53,440

of it so we can actually get better view

1139
00:41:57,910 --> 00:41:55,440
of what we're doing so this is actually

1140
00:41:59,589 --> 00:41:57,920
because it's specialized toward the

1141
00:42:02,470 --> 00:41:59,599
manipulation

1142
00:42:04,790 --> 00:42:02,480
using the human model of

1143
00:42:07,270 --> 00:42:04,800
arms specialized arms and a head and

1144
00:42:09,510 --> 00:42:07,280
neck made more sense

1145
00:42:11,750 --> 00:42:09,520
now one of the neat things about it is

1146
00:42:13,510 --> 00:42:11,760
because these are really robust arms and

1147
00:42:15,990 --> 00:42:13,520
we have this long

1148
00:42:19,510 --> 00:42:16,000
articulated spine we can do nifty things

1149
00:42:21,430 --> 00:42:19,520
like lean over and brace ourselves with

1150
00:42:23,910 --> 00:42:21,440
one limb while reaching with the other

1151
00:42:27,030 --> 00:42:23,920
one and so this is another sort of first

1152
00:42:28,550 --> 00:42:27,040
of kind demonstration

1153
00:42:30,390 --> 00:42:28,560
now

1154
00:42:31,349 --> 00:42:30,400
so giving you that robot because i'm

1155
00:42:33,430 --> 00:42:31,359
going to show you some of the

1156
00:42:35,270 --> 00:42:33,440
demonstrations of software based on that

1157
00:42:37,430 --> 00:42:35,280
because they're very similar to the ones

1158
00:42:39,030 --> 00:42:37,440
we use in robosimian so we want to break

1159
00:42:41,430 --> 00:42:39,040
things up the robot needs to do the

1160
00:42:43,670 --> 00:42:41,440
human hard things humans are really bad

1161
00:42:46,230 --> 00:42:43,680
about directing robots at the joint

1162
00:42:47,750 --> 00:42:46,240
level to do anything

1163
00:42:50,069 --> 00:42:47,760

they're also

1164
00:42:51,829 --> 00:42:50,079
obviously not as good about trying to

1165
00:42:53,750 --> 00:42:51,839
pull in on the information so pictures

1166
00:42:55,270 --> 00:42:53,760
they're going to come back in 2d and the

1167
00:42:56,950 --> 00:42:55,280
humans really have no way of combining

1168
00:42:58,470 --> 00:42:56,960
those things up and sending that

1169
00:42:59,829 --> 00:42:58,480
information back to the robot in any

1170
00:43:02,150 --> 00:42:59,839
useful manner so

1171
00:43:04,710 --> 00:43:02,160
what we want the robot to do is build

1172
00:43:06,309 --> 00:43:04,720
its 3d map of the world itself so it's

1173
00:43:08,550 --> 00:43:06,319
going to do all the nifty math after it

1174
00:43:12,150 --> 00:43:08,560
takes in the pictures and

1175
00:43:13,670 --> 00:43:12,160
the laser rangefinder that's on it

1176
00:43:14,790 --> 00:43:13,680
it's going to execute these behaviors

1177
00:43:15,589 --> 00:43:14,800
and we'll talk about those a little bit

1178
00:43:18,550 --> 00:43:15,599
more

1179
00:43:21,990 --> 00:43:18,560
and then at the very end of it a human

1180
00:43:23,430 --> 00:43:22,000
to control the joystick the robot in a

1181
00:43:27,349 --> 00:43:23,440
way that it doesn't when it touches

1182
00:43:29,030 --> 00:43:27,359
things doesn't mess up is hard

1183
00:43:31,270 --> 00:43:29,040
however the robot can sense it and if it

1184
00:43:33,589 --> 00:43:31,280
senses it it can actually stop itself so

1185
00:43:34,630 --> 00:43:33,599
it's got that last little bit of control

1186
00:43:36,309 --> 00:43:34,640
as well

1187
00:43:38,870 --> 00:43:36,319
the things that the human does the

1188
00:43:40,870 --> 00:43:38,880

robots are rotten at at the moment

1189
00:43:43,589 --> 00:43:40,880
object recognition so the classic

1190
00:43:46,790 --> 00:43:43,599
example is ask a person from anywhere in

1191
00:43:48,470 --> 00:43:46,800
the world what a chair is and show them

1192
00:43:50,230 --> 00:43:48,480
things

1193
00:43:51,829 --> 00:43:50,240
the probability is the person is going

1194
00:43:54,069 --> 00:43:51,839
to have a high rate of success at doing

1195
00:43:56,069 --> 00:43:54,079
that that's a very difficult thing to

1196
00:43:58,309 --> 00:43:56,079
get across to a robot

1197
00:43:59,829 --> 00:43:58,319
because all of the rules that you'd want

1198
00:44:01,349 --> 00:43:59,839
to have it's like well a chair is a

1199
00:44:03,109 --> 00:44:01,359
thing with

1200
00:44:04,390 --> 00:44:03,119
legs well

1201
00:44:08,870 --> 00:44:04,400
sometimes

1202
00:44:10,710 --> 00:44:08,880
because it's sort of on a little

1203
00:44:11,589 --> 00:44:10,720
pedestal and yeah you know the robot's

1204
00:44:13,750 --> 00:44:11,599
like

1205
00:44:15,990 --> 00:44:13,760
time out

1206
00:44:18,390 --> 00:44:16,000
but a human that's a chair

1207
00:44:21,270 --> 00:44:18,400
in our case we care about valves for

1208
00:44:23,750 --> 00:44:21,280
instance or doors and the robot trying

1209
00:44:25,589 --> 00:44:23,760
to figure out a valve of all the valves

1210
00:44:27,829 --> 00:44:25,599
we could download the catalog of all

1211
00:44:29,750 --> 00:44:27,839
known valves you know the master catalog

1212
00:44:31,270 --> 00:44:29,760
straight into its brain and it would

1213
00:44:33,670 --> 00:44:31,280

might get some of that but what if that

1214
00:44:34,550 --> 00:44:33,680
valve was now bent in some other way

1215
00:44:36,390 --> 00:44:34,560
well we'd have to come up with

1216
00:44:38,870 --> 00:44:36,400
algorithms which we can that would allow

1217
00:44:40,309 --> 00:44:38,880
the robot to recognize it but it's hard

1218
00:44:42,630 --> 00:44:40,319
what we've got on this planet are

1219
00:44:45,349 --> 00:44:42,640
billions of people who know what a valve

1220
00:44:46,790 --> 00:44:45,359
is so just let the people do it

1221
00:44:47,829 --> 00:44:46,800
you know someday robots will be smart

1222
00:44:49,349 --> 00:44:47,839
enough to figure that stuff out for

1223
00:44:51,589 --> 00:44:49,359
themselves but but we're not interested

1224
00:44:53,990 --> 00:44:51,599
in someday we're interested in soon and

1225
00:44:56,069 --> 00:44:54,000
soon means people are the ones figuring

1226
00:44:59,190 --> 00:44:56,079
that stuff out

1227
00:45:01,430 --> 00:44:59,200
and then the the user can give the robot

1228
00:45:03,109 --> 00:45:01,440
cheats so in the case of the valve which

1229
00:45:05,270 --> 00:45:03,119
we'll we'll talk about a little bit the

1230
00:45:07,670 --> 00:45:05,280
robe the operator actually just sticks

1231
00:45:09,270 --> 00:45:07,680
the valve on top of the world map for

1232
00:45:11,910 --> 00:45:09,280
the robot to use

1233
00:45:14,950 --> 00:45:11,920
in its planning

1234
00:45:16,150 --> 00:45:14,960
so other key things right these are

1235
00:45:17,030 --> 00:45:16,160
things that the robot needs to be able

1236
00:45:18,470 --> 00:45:17,040
to do

1237
00:45:21,109 --> 00:45:18,480
use some illustrations at the same time

1238
00:45:23,190 --> 00:45:21,119

of of what the robosimian body plan does

1239
00:45:25,190 --> 00:45:23,200
so we got to plan all of this stuff and

1240
00:45:27,030 --> 00:45:25,200
there's some fantastic math and i'll

1241
00:45:28,470 --> 00:45:27,040
point to the front row

1242
00:45:29,750 --> 00:45:28,480
that's some of the people that are doing

1243
00:45:32,150 --> 00:45:29,760
the fancy math

1244
00:45:33,430 --> 00:45:32,160
that's my term

1245
00:45:34,790 --> 00:45:33,440
you can ask him later what he actually

1246
00:45:36,470 --> 00:45:34,800
calls it

1247
00:45:38,470 --> 00:45:36,480
so it takes fancy math to actually plan

1248
00:45:41,109 --> 00:45:38,480
all of this stuff and it can't just be

1249
00:45:43,349 --> 00:45:41,119
plan one limb and what it does and those

1250
00:45:44,470 --> 00:45:43,359
seven degrees of freedom it's got to be

1251
00:45:46,550 --> 00:45:44,480
plan

1252
00:45:48,550 --> 00:45:46,560
what the entire body does at any one

1253
00:45:49,589 --> 00:45:48,560
time

1254
00:45:51,109 --> 00:45:49,599
the other bit is you've got to move

1255
00:45:53,430 --> 00:45:51,119
around in the real world

1256
00:45:56,069 --> 00:45:53,440
so in this lower left this is collision

1257
00:45:58,069 --> 00:45:56,079
checking so i'd like to reach over there

1258
00:45:59,829 --> 00:45:58,079
well there's a bunch of stuff there how

1259
00:46:01,829 --> 00:45:59,839
do i reach in there and actually trying

1260
00:46:03,910 --> 00:46:01,839
to figure out what you want to do

1261
00:46:07,030 --> 00:46:03,920
doesn't collide into something else

1262
00:46:08,470 --> 00:46:07,040
is a difficult problem in itself

1263
00:46:11,270 --> 00:46:08,480

so there's a

1264
00:46:12,870 --> 00:46:11,280
there's software that takes care of that

1265
00:46:16,069 --> 00:46:12,880
and then finally sort of in the lower

1266
00:46:17,990 --> 00:46:16,079
right is a bit of the the whole body

1267
00:46:21,109 --> 00:46:18,000
aspect of that so now moving around in

1268
00:46:24,230 --> 00:46:21,119
that 3d environment in a way

1269
00:46:27,910 --> 00:46:24,240
and planning how to do that properly

1270
00:46:29,990 --> 00:46:27,920
so a little bit more detail on that

1271
00:46:30,870 --> 00:46:30,000
so on the top

1272
00:46:33,589 --> 00:46:30,880
is

1273
00:46:37,829 --> 00:46:33,599
robosimian showing that kind of body

1274
00:46:39,750 --> 00:46:37,839
motion so robosimian just sitting on its

1275
00:46:41,510 --> 00:46:39,760
feet we'll call them for a second

1276
00:46:42,870 --> 00:46:41,520
sitting on its feet and trying to reach

1277
00:46:44,790 --> 00:46:42,880
with just one limb without moving the

1278
00:46:45,829 --> 00:46:44,800
rest of its body doesn't have a lot of

1279
00:46:48,309 --> 00:46:45,839
reach

1280
00:46:49,750 --> 00:46:48,319
robosimian rolling its whole body

1281
00:46:51,750 --> 00:46:49,760
planning what to do with all of those

1282
00:46:53,829 --> 00:46:51,760
limbs at any one time actually has

1283
00:46:55,910 --> 00:46:53,839
pretty considerable reach and it's got

1284
00:47:00,150 --> 00:46:55,920
to plan all of that while keeping itself

1285
00:47:03,829 --> 00:47:01,109
and then

1286
00:47:06,230 --> 00:47:03,839
the same sort of thing but for surrogate

1287
00:47:09,190 --> 00:47:06,240
down at the bottom and in this case it's

1288
00:47:14,069 --> 00:47:09,200

using its spine and its limb at the same

1289
00:47:14,079 --> 00:47:18,630
so rolling all that stuff together

1290
00:47:23,270 --> 00:47:21,750
here's a robust or a surrogate

1291
00:47:24,870 --> 00:47:23,280
doing a valve turn

1292
00:47:26,470 --> 00:47:24,880
we really love turning valves valves is

1293
00:47:27,910 --> 00:47:26,480
great

1294
00:47:29,910 --> 00:47:27,920
so it looks out into the world with its

1295
00:47:33,190 --> 00:47:29,920
eyes its cameras

1296
00:47:35,270 --> 00:47:33,200
builds a 3d environment

1297
00:47:37,030 --> 00:47:35,280
it actually we have some

1298
00:47:38,710 --> 00:47:37,040
other fancy math that actually lets it

1299
00:47:40,870 --> 00:47:38,720
figure out where to park itself so that

1300
00:47:41,829 --> 00:47:40,880
it can do its job

1301
00:47:43,430 --> 00:47:41,839
later

1302
00:47:45,270 --> 00:47:43,440
it's going to come up

1303
00:47:46,950 --> 00:47:45,280
it's going to say hey operator i've got

1304
00:47:49,030 --> 00:47:46,960
this thing in front of me what do i do

1305
00:47:50,710 --> 00:47:49,040
with it and the operator is going to say

1306
00:47:52,870 --> 00:47:50,720
here's what you're interested in and i

1307
00:47:55,990 --> 00:47:52,880
want you to and you notice there's

1308
00:47:57,589 --> 00:47:56,000
basically noun verb you know it's a this

1309
00:47:59,109 --> 00:47:57,599
is the behavior i want you to do this

1310
00:48:00,150 --> 00:47:59,119
thing to this thing and i'll tell you

1311
00:48:02,150 --> 00:48:00,160
what it is

1312
00:48:03,990 --> 00:48:02,160
and then the robot takes over again and

1313
00:48:06,790 --> 00:48:04,000

it says okay well i got to grab this

1314
00:48:08,150 --> 00:48:06,800
valve and i gotta turn it and it plans

1315
00:48:13,190 --> 00:48:08,160
for itself

1316
00:48:16,390 --> 00:48:14,790
now you see it's using uh some

1317
00:48:17,829 --> 00:48:16,400
commercially available grippers here

1318
00:48:19,270 --> 00:48:17,839
that aren't

1319
00:48:20,710 --> 00:48:19,280
these are the ones that that we found

1320
00:48:23,349 --> 00:48:20,720
not to be quite strong enough to do most

1321
00:48:25,430 --> 00:48:23,359
of what we would like

1322
00:48:29,430 --> 00:48:25,440
and if you're watching it's moving both

1323
00:48:31,030 --> 00:48:29,440
its limbs and its spine at the same time

1324
00:48:33,510 --> 00:48:31,040
and it's not as obvious in this case but

1325
00:48:35,430 --> 00:48:33,520
the other limb in certain moves is also

1326
00:48:37,270 --> 00:48:35,440
there to keep stability so if it's

1327
00:48:38,390 --> 00:48:37,280
reaching you'll actually see it move if

1328
00:48:39,510 --> 00:48:38,400
it's reaching out with this one it'll

1329
00:48:41,190 --> 00:48:39,520
actually move the other one out so you

1330
00:48:46,829 --> 00:48:41,200
get a little surfing action

1331
00:48:50,309 --> 00:48:48,630
so um

1332
00:48:52,790 --> 00:48:50,319
is all that coming around back to the

1333
00:48:54,390 --> 00:48:52,800
trials so this is what it looks like

1334
00:48:57,109 --> 00:48:54,400
this is you know we showed you a little

1335
00:48:59,190 --> 00:48:57,119
bit before it's a you know man's uh

1336
00:49:00,470 --> 00:48:59,200
human scale so it's relatively easy to

1337
00:49:02,309 --> 00:49:00,480
pick up it's robust so we're not really

1338
00:49:05,030 --> 00:49:02,319

worried about it so we just grab it take

1339
00:49:07,109 --> 00:49:05,040
it where it needs to go

1340
00:49:08,309 --> 00:49:07,119
and do does what it needs to do so this

1341
00:49:10,549 --> 00:49:08,319
happens to be a little bit more of the

1342
00:49:11,510 --> 00:49:10,559
video of clearing out the debris one of

1343
00:49:13,910 --> 00:49:11,520
the other reasons to look at this

1344
00:49:15,990 --> 00:49:13,920
particular video is because we have this

1345
00:49:17,750 --> 00:49:16,000
generalized system it actually allows

1346
00:49:19,829 --> 00:49:17,760
the operators to figure out new ways to

1347
00:49:22,069 --> 00:49:19,839
use it that we didn't expect in this

1348
00:49:23,829 --> 00:49:22,079
case it was how do we get all these

1349
00:49:25,109 --> 00:49:23,839
pieces of debris out of the way

1350
00:49:28,630 --> 00:49:25,119
the

1351
00:49:29,910 --> 00:49:28,640
thought what was going to happen is that

1352
00:49:32,309 --> 00:49:29,920
they would people would come in and

1353
00:49:36,390 --> 00:49:32,319
they'd grab every individual piece of

1354
00:49:38,390 --> 00:49:36,400
debris and dump it over the side

1355
00:49:40,390 --> 00:49:38,400
we decided that was

1356
00:49:42,230 --> 00:49:40,400
inefficient

1357
00:49:44,390 --> 00:49:42,240
so

1358
00:49:46,230 --> 00:49:44,400
we roll up to it

1359
00:49:47,670 --> 00:49:46,240
take a look at it

1360
00:49:48,950 --> 00:49:47,680
you don't see the sweat coming off the

1361
00:49:51,750 --> 00:49:48,960
two guys that are

1362
00:49:54,790 --> 00:49:51,760
but there is a little stress

1363
00:49:56,150 --> 00:49:54,800

so they're grabbing these things

1364
00:49:57,750 --> 00:49:56,160
wait for it

1365
00:49:59,190 --> 00:49:57,760
zero points

1366
00:50:03,270 --> 00:49:59,200
not doing well

1367
00:50:05,750 --> 00:50:04,390
by the way you'll notice that the robot

1368
00:50:08,549 --> 00:50:05,760
doesn't move very much and the operators

1369
00:50:12,230 --> 00:50:09,990
this is why we want to be a patient

1370
00:50:13,750 --> 00:50:12,240
robot because robots will always be

1371
00:50:15,510 --> 00:50:13,760
waiting for humans to come up with a

1372
00:50:18,390 --> 00:50:15,520
really creative solution

1373
00:50:22,870 --> 00:50:18,400
oh let's just grab this thing and we'll

1374
00:50:26,230 --> 00:50:24,710
so we actually cleared and i forgot we

1375
00:50:28,630 --> 00:50:26,240
got one point for every five pieces of

1376
00:50:29,910 --> 00:50:28,640
wood or something like that so

1377
00:50:31,990 --> 00:50:29,920
we were able to

1378
00:50:33,430 --> 00:50:32,000
go in there and then clear it all out

1379
00:50:36,470 --> 00:50:33,440
so we actually ended up getting full

1380
00:50:37,510 --> 00:50:36,480
points for that particular

1381
00:50:39,430 --> 00:50:37,520
thing

1382
00:50:41,750 --> 00:50:39,440
so uh lessons learned

1383
00:50:44,309 --> 00:50:41,760
this interesting thing is that in the

1384
00:50:48,630 --> 00:50:44,319
top by the way we finished fifth out of

1385
00:50:51,430 --> 00:50:48,640
16 teams we're quite proud of that um

1386
00:50:54,230 --> 00:50:51,440
but of the five top teams

1387
00:50:56,790 --> 00:50:54,240
uh we call ourselves the cool kids out

1388
00:50:59,349 --> 00:50:56,800

of the cool kids there were humanoids

1389
00:51:01,589 --> 00:50:59,359
and there were robots like uh robosimian

1390
00:51:04,790 --> 00:51:01,599
and actually another one called chimp

1391
00:51:06,309 --> 00:51:04,800
from uh carnegie mellon university and

1392
00:51:09,030 --> 00:51:06,319
chimp as you might expect kind of looks

1393
00:51:13,670 --> 00:51:09,040
a little bit like robosimian

1394
00:51:17,589 --> 00:51:15,510
that having a flexible system is a

1395
00:51:19,030 --> 00:51:17,599
really good thing

1396
00:51:21,349 --> 00:51:19,040
and that we can let the operators

1397
00:51:23,430 --> 00:51:21,359
explore what how it does everything

1398
00:51:25,109 --> 00:51:23,440
however you know one of the things

1399
00:51:28,150 --> 00:51:25,119
that's still hard is translating these

1400
00:51:30,630 --> 00:51:28,160
human goals into robot goals and trying

1401
00:51:31,829 --> 00:51:30,640
how to do that effectively

1402
00:51:33,750 --> 00:51:31,839
and then

1403
00:51:35,990 --> 00:51:33,760
frankly trying to figure out how to

1404
00:51:37,349 --> 00:51:36,000
balance the dexterity of your robot and

1405
00:51:39,109 --> 00:51:37,359
the robustness of the robot it's easy to

1406
00:51:40,870 --> 00:51:39,119
build a robust robot it's easy to build

1407
00:51:41,750 --> 00:51:40,880
a dexterous robot it's really hard to

1408
00:51:44,150 --> 00:51:41,760
build

1409
00:51:46,069 --> 00:51:44,160
anything that combines those two things

1410
00:51:48,870 --> 00:51:46,079
so and we're still trying to find the

1411
00:51:52,470 --> 00:51:48,880
sweet spot of that relative to the job

1412
00:51:54,950 --> 00:51:53,910
for a completeness sake i was going to

1413
00:51:57,190 --> 00:51:54,960

point out that we actually have other

1414
00:51:59,829 --> 00:51:57,200
limbed robots here at jpl they're really

1415
00:52:02,309 --> 00:51:59,839
big ones like athlete which

1416
00:52:03,990 --> 00:52:02,319
is basically the coolest truck in the

1417
00:52:06,950 --> 00:52:04,000
solar system

1418
00:52:07,990 --> 00:52:06,960
it will load and unload itself for you

1419
00:52:10,150 --> 00:52:08,000
uh

1420
00:52:11,829 --> 00:52:10,160
and then in the middle we have got cave

1421
00:52:14,390 --> 00:52:11,839
climbing robots

1422
00:52:16,390 --> 00:52:14,400
the lemur systems hopefully it will be

1423
00:52:19,349 --> 00:52:16,400
deployed into the caves of new mexico

1424
00:52:21,109 --> 00:52:19,359
sometime later this year and systems

1425
00:52:22,870 --> 00:52:21,119
that are very similar to that it turns

1426
00:52:25,190 --> 00:52:22,880
out that climbing around on the outside

1427
00:52:26,710 --> 00:52:25,200
of spacecraft for inspection purposes is

1428
00:52:28,549 --> 00:52:26,720
basically the same type of robotics

1429
00:52:30,710 --> 00:52:28,559
problems climbing around inside of caves

1430
00:52:32,710 --> 00:52:30,720
you just swap your micro spine grippers

1431
00:52:35,190 --> 00:52:32,720
which are for the caves

1432
00:52:36,150 --> 00:52:35,200
for artificial gecko adhesive

1433
00:52:39,270 --> 00:52:36,160
to climb around the outside of

1434
00:52:45,990 --> 00:52:40,069
so

1435
00:52:47,990 --> 00:52:46,000
complete list but it is basically

1436
00:52:51,670 --> 00:52:48,000
the core of folks who have in some way

1437
00:52:54,630 --> 00:52:51,680
or another made robosimian possible

1438
00:52:58,069 --> 00:52:54,640

jpl long list of folks

1439
00:52:59,750 --> 00:52:58,079
ucsb caltech and stanford

1440
00:53:01,670 --> 00:52:59,760
and the art institute have all

1441
00:53:04,309 --> 00:53:01,680
contributed in some way or another to to

1442
00:53:06,390 --> 00:53:04,319
what you saw here today

1443
00:53:10,470 --> 00:53:06,400
and then it's always nice to

1444
00:53:20,150 --> 00:53:12,710
and i'd say with that we can we can open

1445
00:53:24,230 --> 00:53:22,470
so there's a microphone out there i do

1446
00:53:25,349 --> 00:53:24,240
believe the idea is that if you'd like

1447
00:53:26,549 --> 00:53:25,359
to ask a question you should find your

1448
00:53:29,510 --> 00:53:26,559
way to a microphone

1449
00:53:30,630 --> 00:53:29,520
yeah um a couple quick questions i know

1450
00:53:33,270 --> 00:53:30,640
you guys like your acronyms i'm

1451
00:53:35,349 --> 00:53:33,280
wondering what athelete stands for

1452
00:53:36,870 --> 00:53:35,359
john what does athlete stand for

1453
00:53:39,829 --> 00:53:36,880
all terrain

1454
00:53:42,630 --> 00:53:39,839
extraterrestrial explorer

1455
00:53:44,150 --> 00:53:42,640
i knew somebody would know um

1456
00:53:45,750 --> 00:53:44,160
and i'm sorry if you answered this

1457
00:53:47,109 --> 00:53:45,760
earlier uh were there weight

1458
00:53:48,309 --> 00:53:47,119
restrictions put on this thing or how

1459
00:53:50,790 --> 00:53:48,319
much does it weigh

1460
00:53:52,630 --> 00:53:50,800
uh so it weighs about 125 kilos there

1461
00:53:54,870 --> 00:53:52,640
are no weight restrictions

1462
00:53:57,430 --> 00:53:54,880
uh there but there are practical limits

1463
00:53:59,270 --> 00:53:57,440

to how big your robot can be because it

1464
00:54:01,270 --> 00:53:59,280
has to fit into these human human type

1465
00:54:05,510 --> 00:54:01,280
of environments so

1466
00:54:06,790 --> 00:54:05,520
uh i believe uh chimp is closer to

1467
00:54:08,790 --> 00:54:06,800
well so

1468
00:54:10,230 --> 00:54:08,800
i'll switch units on you and i apologize

1469
00:54:12,790 --> 00:54:10,240
so i think it's like closer to 400

1470
00:54:15,349 --> 00:54:12,800
pounds so the atlas systems are 300

1471
00:54:17,829 --> 00:54:15,359
pound-ish um we're kind of in the middle

1472
00:54:18,870 --> 00:54:17,839
and i think the smallest robots are

1473
00:54:21,910 --> 00:54:18,880
uh

1474
00:54:22,829 --> 00:54:21,920
100 pound-ish the hubos are roughly in

1475
00:54:25,589 --> 00:54:22,839
that

1476
00:54:27,510 --> 00:54:25,599
category um okay and then my uh final

1477
00:54:29,109 --> 00:54:27,520
question um it was just just kind of a

1478
00:54:31,430 --> 00:54:29,119
general question about the the power

1479
00:54:32,870 --> 00:54:31,440
source and like you know limitations

1480
00:54:34,950 --> 00:54:32,880
you've had struggles you've had with

1481
00:54:37,829 --> 00:54:34,960
that and how it affects the design and

1482
00:54:39,589 --> 00:54:37,839
yeah so the strength of it you know

1483
00:54:42,150 --> 00:54:39,599
so it's all electric

1484
00:54:42,950 --> 00:54:42,160
and on purpose this is a very

1485
00:54:44,710 --> 00:54:42,960
uh

1486
00:54:46,710 --> 00:54:44,720
well-known technology

1487
00:54:49,030 --> 00:54:46,720
this electric stuff

1488
00:54:50,870 --> 00:54:49,040

and we actually borrowed

1489
00:54:53,829 --> 00:54:50,880
the design of the battery that runs this

1490
00:54:55,510 --> 00:54:53,839
from electric motorcycles this has been

1491
00:54:57,030 --> 00:54:55,520
the fact that we now have hybrids and

1492
00:54:59,190 --> 00:54:57,040
electric cars has been great for the

1493
00:55:01,829 --> 00:54:59,200
stuff we do because now and actually

1494
00:55:03,109 --> 00:55:01,839
laptops which is where so all the

1495
00:55:05,510 --> 00:55:03,119
vehicle batteries are actually coming

1496
00:55:07,829 --> 00:55:05,520
from laptop technology so

1497
00:55:09,670 --> 00:55:07,839
we now have these very compact power

1498
00:55:12,069 --> 00:55:09,680
sources uh that we can use and that's

1499
00:55:13,589 --> 00:55:12,079
been great it's still pretty challenging

1500
00:55:15,829 --> 00:55:13,599
to put

1501
00:55:17,829 --> 00:55:15,839
so for all the the

1502
00:55:20,309 --> 00:55:17,839
well for all the people who like does

1503
00:55:21,589 --> 00:55:20,319
somebody say geeks you know so for all

1504
00:55:23,270 --> 00:55:21,599
the nerds in the in the audience we

1505
00:55:25,990 --> 00:55:23,280
actually have a two kilowatt hour

1506
00:55:28,950 --> 00:55:26,000
battery in there so that should be able

1507
00:55:30,870 --> 00:55:28,960
and getting that much uh energy in such

1508
00:55:33,829 --> 00:55:30,880
a small space is is a relatively new

1509
00:55:35,910 --> 00:55:33,839
thing but you know that's that's been a

1510
00:55:37,430 --> 00:55:35,920
huge benefit to get the the technology

1511
00:55:41,270 --> 00:55:37,440
from other industries

1512
00:55:45,990 --> 00:55:43,990
uh my question has several parts uh

1513
00:55:47,750 --> 00:55:46,000

your actuator you showed does it have

1514
00:55:48,870 --> 00:55:47,760
any gears in it

1515
00:55:50,069 --> 00:55:48,880
yes

1516
00:55:51,589 --> 00:55:50,079
so this

1517
00:55:53,190 --> 00:55:51,599
let me pull it back out

1518
00:55:54,789 --> 00:55:53,200
i didn't really go through the elements

1519
00:55:56,549 --> 00:55:54,799
of it

1520
00:55:58,230 --> 00:55:56,559
so my question is does it have

1521
00:55:59,430 --> 00:55:58,240
limitations on how fast it can

1522
00:56:01,190 --> 00:55:59,440
accelerate

1523
00:56:03,430 --> 00:56:01,200
and the reason i'm i'm interested in

1524
00:56:05,430 --> 00:56:03,440
that is eventually you want to have

1525
00:56:08,069 --> 00:56:05,440
bipedal motion

1526
00:56:12,150 --> 00:56:08,079
and it is it am i correct in saying if

1527
00:56:14,710 --> 00:56:12,160
you're trying to walk like a human walks

1528
00:56:17,190 --> 00:56:14,720
you have a certain pendulum

1529
00:56:19,510 --> 00:56:17,200
and you have you have certain

1530
00:56:22,950 --> 00:56:19,520
you you have to you have to have certain

1531
00:56:25,270 --> 00:56:22,960
rates of of uh of speed and acceleration

1532
00:56:29,190 --> 00:56:25,280
to avoid falling over

1533
00:56:33,109 --> 00:56:30,789
we differentiate this is sort of the

1534
00:56:35,829 --> 00:56:33,119
taurus and the hair and the tortoise

1535
00:56:37,990 --> 00:56:35,839
uses what we refer to as quasi-static

1536
00:56:40,069 --> 00:56:38,000
motion which is basically what we are

1537
00:56:41,750 --> 00:56:40,079
right so you could freeze this robot at

1538
00:56:42,710 --> 00:56:41,760

any point in time and it wouldn't fall

1539
00:56:45,030 --> 00:56:42,720
over

1540
00:56:46,710 --> 00:56:45,040
that's different than actually most

1541
00:56:49,030 --> 00:56:46,720
everything else that moves around which

1542
00:56:51,670 --> 00:56:49,040
is dynamic motion in some way or another

1543
00:56:53,910 --> 00:56:51,680
so whether you're quadrupedal or bipedal

1544
00:56:54,950 --> 00:56:53,920
most animals get around in a dynamic

1545
00:56:56,230 --> 00:56:54,960
mode

1546
00:56:58,309 --> 00:56:56,240
sort of the pendulum action that you're

1547
00:57:00,950 --> 00:56:58,319
talking about and yes you do need to

1548
00:57:02,309 --> 00:57:00,960
move fast enough to make that happen or

1549
00:57:04,789 --> 00:57:02,319
in this case you have to actually be

1550
00:57:06,390 --> 00:57:04,799
able to produce enough power to move a

1551
00:57:09,030 --> 00:57:06,400
certain mass

1552
00:57:11,750 --> 00:57:09,040
that fast and so that actually is a

1553
00:57:14,630 --> 00:57:11,760
significant issue for us because

1554
00:57:16,870 --> 00:57:14,640
normal off-the-shelf technologies don't

1555
00:57:19,270 --> 00:57:16,880
give us enough power density

1556
00:57:21,750 --> 00:57:19,280
to to pull that off

1557
00:57:23,589 --> 00:57:21,760
for instance one way around that is a

1558
00:57:25,750 --> 00:57:23,599
lot of the the bipedal systems have

1559
00:57:27,109 --> 00:57:25,760
hydraulics instead and so the power

1560
00:57:29,990 --> 00:57:27,119
density of the hydraulic system is

1561
00:57:31,589 --> 00:57:30,000
better but hydraulics as a system are

1562
00:57:33,190 --> 00:57:31,599
maybe not as much you don't want to do

1563
00:57:36,470 --> 00:57:33,200

that yeah right right all right so

1564
00:57:38,309 --> 00:57:36,480
that's coming thanks yeah

1565
00:57:42,069 --> 00:57:38,319
um

1566
00:57:44,630 --> 00:57:42,079
so you're the robot i noticed that the

1567
00:57:46,470 --> 00:57:44,640
valves that were shown on the

1568
00:57:48,950 --> 00:57:46,480
presentation were

1569
00:57:51,190 --> 00:57:48,960
you were facing it horizontally

1570
00:57:53,109 --> 00:57:51,200
does it have limitations on

1571
00:57:55,349 --> 00:57:53,119
valves or something like that that would

1572
00:57:57,349 --> 00:57:55,359
be on the ground or on the ceiling

1573
00:57:58,150 --> 00:57:57,359
uh as long as it could reach it probably

1574
00:58:00,710 --> 00:57:58,160
not

1575
00:58:02,470 --> 00:58:00,720
so we talk about what the robot can do

1576
00:58:03,670 --> 00:58:02,480
and just like yourself like you can

1577
00:58:05,589 --> 00:58:03,680
actually get yourself bound up in a

1578
00:58:07,109 --> 00:58:05,599
position where you can't

1579
00:58:08,710 --> 00:58:07,119
get to what you're trying to do so if i

1580
00:58:11,430 --> 00:58:08,720
got my arm stuck kind of up in here you

1581
00:58:13,990 --> 00:58:11,440
really can't do much either so as long

1582
00:58:16,309 --> 00:58:14,000
as the robot can put that valve

1583
00:58:18,549 --> 00:58:16,319
in a space relative to itself

1584
00:58:20,789 --> 00:58:18,559
that it can make this motion

1585
00:58:22,230 --> 00:58:20,799
then it shouldn't have a problem whether

1586
00:58:23,829 --> 00:58:22,240
it's down on the ground or on the

1587
00:58:25,349 --> 00:58:23,839
ceiling obviously if you can't reach it

1588
00:58:26,950 --> 00:58:25,359

that's a problem too

1589
00:58:29,670 --> 00:58:26,960
in robosimian's case that's an

1590
00:58:30,630 --> 00:58:29,680
interesting problem if it's up above

1591
00:58:32,630 --> 00:58:30,640
because

1592
00:58:33,990 --> 00:58:32,640
while we can go bipedal it's only if we

1593
00:58:35,589 --> 00:58:34,000
have something to work with so we have

1594
00:58:37,190 --> 00:58:35,599
to climb up the side of a wall to reach

1595
00:58:38,789 --> 00:58:37,200
something higher

1596
00:58:41,349 --> 00:58:38,799
which we can do

1597
00:58:44,230 --> 00:58:41,359
and it works for most ways that these

1598
00:58:46,150 --> 00:58:44,240
types of facilities are built

1599
00:58:47,349 --> 00:58:46,160
but we couldn't just rear up and grab

1600
00:58:49,270 --> 00:58:47,359
something that was up above us that

1601
00:58:51,510 --> 00:58:49,280
would be the basic limitation but

1602
00:58:53,589 --> 00:58:51,520
otherwise you know it's just another 3d

1603
00:58:56,470 --> 00:58:53,599
problem to the to the robot

1604
00:58:58,390 --> 00:58:56,480
then does it have the capability to

1605
00:58:59,990 --> 00:58:58,400
kind of like drag things in the pile

1606
00:59:01,349 --> 00:59:00,000
climb up and then

1607
00:59:04,150 --> 00:59:01,359
do that

1608
00:59:06,950 --> 00:59:04,160
uh sure so it physically would have that

1609
00:59:09,270 --> 00:59:06,960
capability um it doesn't have a software

1610
00:59:11,270 --> 00:59:09,280
behavior for that explicitly at the

1611
00:59:13,349 --> 00:59:11,280
moment and probably if you want to do

1612
00:59:14,950 --> 00:59:13,359
something that complex that's where

1613
00:59:16,390 --> 00:59:14,960

you're again going to you're going to

1614
00:59:17,670 --> 00:59:16,400
trust that you've got a human on the

1615
00:59:19,030 --> 00:59:17,680
other end that's going to come up with a

1616
00:59:21,589 --> 00:59:19,040
creative solution

1617
00:59:23,190 --> 00:59:21,599
like that so looking around in the room

1618
00:59:24,950 --> 00:59:23,200
trying to determine what you could grab

1619
00:59:25,910 --> 00:59:24,960
in the room that's robust enough to pile

1620
00:59:28,069 --> 00:59:25,920
into

1621
00:59:30,230 --> 00:59:28,079
a way of

1622
00:59:32,710 --> 00:59:30,240
getting yourself higher

1623
00:59:34,230 --> 00:59:32,720
and all and my final question is you

1624
00:59:37,030 --> 00:59:34,240
know you said that

1625
00:59:39,270 --> 00:59:37,040
when the camera gets a

1626
00:59:40,710 --> 00:59:39,280
image and sends it to the computer you

1627
00:59:43,349 --> 00:59:40,720
can't figure out

1628
00:59:47,109 --> 00:59:43,359
sort of the 3d stuff

1629
00:59:49,190 --> 00:59:47,119
if you just have a um like

1630
00:59:50,950 --> 00:59:49,200
the way that the robots design like if

1631
00:59:51,990 --> 00:59:50,960
you had a camera on like the shoulders

1632
00:59:54,069 --> 00:59:52,000
can't you

1633
00:59:56,069 --> 00:59:54,079
do like a bunch of trigonometry stuff

1634
00:59:58,309 --> 00:59:56,079
and figure out how

1635
01:00:00,150 --> 00:59:58,319
far stuff is actually that's exactly

1636
01:00:02,150 --> 01:00:00,160
what the robot's doing so you just

1637
01:00:03,589 --> 01:00:02,160
described machine vision so now you

1638
01:00:04,710 --> 01:00:03,599

don't need an advanced degree to do that

1639
01:00:05,750 --> 01:00:04,720
because you just figured it out for

1640
01:00:08,230 --> 01:00:05,760
yourself

1641
01:00:10,630 --> 01:00:08,240
which is great so so yeah you don't the

1642
01:00:12,150 --> 01:00:10,640
the but the person like you don't

1643
01:00:14,710 --> 01:00:12,160
if it's just pictures that are shown to

1644
01:00:17,190 --> 01:00:14,720
the person the operator the operator

1645
01:00:18,870 --> 01:00:17,200
can't do that math that's going to then

1646
01:00:20,870 --> 01:00:18,880
turn into an instruction back to the

1647
01:00:23,270 --> 01:00:20,880
robot so that's why the robot we want

1648
01:00:25,589 --> 01:00:23,280
the the robot building the map um then

1649
01:00:27,430 --> 01:00:25,599
can't you send that into like an oculus

1650
01:00:28,390 --> 01:00:27,440
rift or something and then have it like

1651
01:00:30,549 --> 01:00:28,400
that

1652
01:00:32,069 --> 01:00:30,559
yes absolutely but the interesting thing

1653
01:00:33,910 --> 01:00:32,079
is if you send it to the oculus rift

1654
01:00:34,710 --> 01:00:33,920
you've already created the map

1655
01:00:39,510 --> 01:00:34,720
so

1656
01:00:41,670 --> 01:00:39,520
it might be a useful way for a human

1657
01:00:43,589 --> 01:00:41,680
operator to interact with the robot

1658
01:00:46,549 --> 01:00:43,599
the robot's not going to base its

1659
01:00:48,390 --> 01:00:46,559
actions on the information that's in the

1660
01:00:50,309 --> 01:00:48,400
oculus rift it's going to base its

1661
01:00:52,710 --> 01:00:50,319
actions on the information that it

1662
01:00:53,670 --> 01:00:52,720
carries around in its own system in its

1663
01:00:55,829 --> 01:00:53,680

own head

1664
01:00:58,150 --> 01:00:55,839
thank you

1665
01:00:59,670 --> 01:00:58,160
hi um so with the software engineering

1666
01:01:01,589 --> 01:00:59,680
behind this was most of these algorithms

1667
01:01:03,670 --> 01:01:01,599
were they written in python or c do you

1668
01:01:05,510 --> 01:01:03,680
know and say is see and is most of the

1669
01:01:07,910 --> 01:01:05,520
is any of this available online for

1670
01:01:12,150 --> 01:01:07,920
people who are doing none of it

1671
01:01:13,270 --> 01:01:12,160
will it be eventually yeah so um

1672
01:01:14,710 --> 01:01:13,280
hmm

1673
01:01:16,549 --> 01:01:14,720
what's the best way to answer this

1674
01:01:18,870 --> 01:01:16,559
question

1675
01:01:22,630 --> 01:01:18,880
it is there are certain people paid for

1676
01:01:24,390 --> 01:01:22,640
it there are certain uh legal hurdles to

1677
01:01:27,750 --> 01:01:24,400
us sharing

1678
01:01:29,750 --> 01:01:27,760
code okay is the short answer or the

1679
01:01:32,630 --> 01:01:29,760
shortest answer i think i've got to to

1680
01:01:35,030 --> 01:01:32,640
that question so hopefully but where you

1681
01:01:37,109 --> 01:01:35,040
would see this stuff is is in published

1682
01:01:39,109 --> 01:01:37,119
papers and things like that so as long

1683
01:01:41,190 --> 01:01:39,119
as you don't mind writing your own code

1684
01:01:44,309 --> 01:01:41,200
the way we did it the the actual

1685
01:01:46,390 --> 01:01:44,319
methodology and the algorithm that

1686
01:01:48,230 --> 01:01:46,400
informed the software is something that

1687
01:01:50,829 --> 01:01:48,240
would be published and

1688
01:01:55,829 --> 01:01:54,230

way um you mentioned early on that this

1689
01:01:58,069 --> 01:01:55,839
is not just an academic project you want

1690
01:01:59,589 --> 01:01:58,079
to be able to actually deploy this

1691
01:02:01,910 --> 01:01:59,599
um

1692
01:02:02,789 --> 01:02:01,920
is there a path organizationally going

1693
01:02:04,630 --> 01:02:02,799
forwards

1694
01:02:07,190 --> 01:02:04,640
the darpa competition is to stimulate

1695
01:02:08,870 --> 01:02:07,200
this kind of technological research

1696
01:02:11,109 --> 01:02:08,880
to sort of

1697
01:02:12,710 --> 01:02:11,119
team up with the other winning teams and

1698
01:02:15,270 --> 01:02:12,720
and cross-pollinate to make a finished

1699
01:02:16,950 --> 01:02:15,280
product or for darpa to take the best of

1700
01:02:18,309 --> 01:02:16,960
all of the team's work and move forward

1701
01:02:21,670 --> 01:02:18,319
with something else or are you planning

1702
01:02:23,829 --> 01:02:21,680
to go it alone moving forward

1703
01:02:25,829 --> 01:02:23,839
so not there's no

1704
01:02:27,430 --> 01:02:25,839
specific mechanism in place to deal with

1705
01:02:28,230 --> 01:02:27,440
it the way you described

1706
01:02:32,870 --> 01:02:28,240
uh

1707
01:02:34,549 --> 01:02:32,880
allowed to do whatever they want because

1708
01:02:37,430 --> 01:02:34,559
it's their intellectual property so for

1709
01:02:39,589 --> 01:02:37,440
instance robosimian both the

1710
01:02:41,670 --> 01:02:39,599
physical design and the software is

1711
01:02:44,230 --> 01:02:41,680
under licensed to a local company here

1712
01:02:46,549 --> 01:02:44,240
called mode of space systems and so they

1713
01:02:49,190 --> 01:02:46,559

are looking for commercial applications

1714
01:02:51,349 --> 01:02:49,200
for for the system and and building them

1715
01:02:53,510 --> 01:02:51,359
uh under license to jpl so there's no

1716
01:02:55,270 --> 01:02:53,520
reason they couldn't go to other teams

1717
01:02:56,710 --> 01:02:55,280
after competition and say we want to

1718
01:02:58,710 --> 01:02:56,720
pull this in yeah no they absolutely

1719
01:03:01,109 --> 01:02:58,720
could yeah and that's probably how a lot

1720
01:03:04,710 --> 01:03:01,119
of this would actually happen uh and now

1721
01:03:06,230 --> 01:03:04,720
um as a interesting aspect to that

1722
01:03:12,549 --> 01:03:06,240
the

1723
01:03:15,510 --> 01:03:12,559
shaft was bought by google

1724
01:03:18,069 --> 01:03:15,520
and boston dynamics which provided

1725
01:03:20,470 --> 01:03:18,079
half of the field with the atlas systems

1726
01:03:22,390 --> 01:03:20,480
uh under contract to darpa was also

1727
01:03:24,710 --> 01:03:22,400
bought by google so

1728
01:03:27,029 --> 01:03:24,720
basically google bought half of the

1729
01:03:28,390 --> 01:03:27,039
competition's technology

1730
01:03:29,510 --> 01:03:28,400
and that's that's the other way it

1731
01:03:32,950 --> 01:03:29,520
happens

1732
01:03:38,470 --> 01:03:36,309
hi i was curious of what type of

1733
01:03:40,630 --> 01:03:38,480
control architecture there is for

1734
01:03:43,670 --> 01:03:40,640
robosimian as far as the motor controls

1735
01:03:46,870 --> 01:03:43,680
go so is it is it centralized control

1736
01:03:48,150 --> 01:03:46,880
decentralized at the axis level yeah so

1737
01:03:49,029 --> 01:03:48,160
so every

1738
01:03:51,270 --> 01:03:49,039

actually

1739
01:03:53,109 --> 01:03:51,280
i have a prop hey i've got a problem uh

1740
01:03:55,750 --> 01:03:53,119
so sitting on top of this is a set of

1741
01:03:57,109 --> 01:03:55,760
electronics um this little magic silver

1742
01:03:58,150 --> 01:03:57,119
box it's not a little black box it's

1743
01:04:00,789 --> 01:03:58,160
actually a little silver box in this

1744
01:04:04,390 --> 01:04:00,799
case is a commercial motor controller

1745
01:04:08,390 --> 01:04:04,400
and it all uh it all speaks ethercat

1746
01:04:10,950 --> 01:04:08,400
and so this is a highly distributed

1747
01:04:13,349 --> 01:04:10,960
architecture for robosimian specifically

1748
01:04:16,789 --> 01:04:13,359
and it allows us to do some things like

1749
01:04:18,309 --> 01:04:16,799
these uh modular uh actuators so we can

1750
01:04:20,470 --> 01:04:18,319
we drop them in that way

1751
01:04:23,109 --> 01:04:20,480
were those were those developed in-house

1752
01:04:24,870 --> 01:04:23,119
or uh purchased no so these actually

1753
01:04:27,589 --> 01:04:24,880
happen to be elmo if you if you're

1754
01:04:30,390 --> 01:04:27,599
interested in the brand name yes so elmo

1755
01:04:32,390 --> 01:04:30,400
controllers they're not you know we are

1756
01:04:34,150 --> 01:04:32,400
applying technology that was not really

1757
01:04:38,230 --> 01:04:34,160
designed for this purpose

1758
01:04:39,270 --> 01:04:38,240
for our our needs um so there's probably

1759
01:04:40,789 --> 01:04:39,280
you know in the future there'll be

1760
01:04:43,029 --> 01:04:40,799
better solutions than this

1761
01:04:46,069 --> 01:04:43,039
are those running in position mode then

1762
01:04:47,829 --> 01:04:46,079
uh at the axis level basically now

1763
01:04:49,670 --> 01:04:47,839

elmo's have in a host of different modes

1764
01:04:52,230 --> 01:04:49,680
that they can actually use so you can

1765
01:04:53,670 --> 01:04:52,240
you can kind of tweak your control to uh

1766
01:04:55,510 --> 01:04:53,680
to meet your need so whether or not

1767
01:04:56,870 --> 01:04:55,520
you're doing you know just trajectory

1768
01:04:58,069 --> 01:04:56,880
following or

1769
01:04:59,349 --> 01:04:58,079
if you're in a force control mode or

1770
01:05:00,950 --> 01:04:59,359
something like that you can move to

1771
01:05:05,270 --> 01:05:00,960
different modes

1772
01:05:08,630 --> 01:05:07,029
so obviously the hands have a lot of

1773
01:05:11,750 --> 01:05:08,640
power in order to lift things like

1774
01:05:13,190 --> 01:05:11,760
cinder blocks and other large materials

1775
01:05:14,630 --> 01:05:13,200
but i noticed that they're also doing

1776
01:05:15,990 --> 01:05:14,640
very delicate things like pressing

1777
01:05:17,190 --> 01:05:16,000
buttons or

1778
01:05:18,549 --> 01:05:17,200
manipulating

1779
01:05:20,150 --> 01:05:18,559
objects that are meant to be manipulated

1780
01:05:22,069 --> 01:05:20,160
by humans who obviously have a lot less

1781
01:05:23,510 --> 01:05:22,079
strength so how is that controlled so

1782
01:05:24,789 --> 01:05:23,520
that obviously we saw that it could cut

1783
01:05:26,069 --> 01:05:24,799
through things like plywood so that it

1784
01:05:28,470 --> 01:05:26,079
doesn't break things that are more

1785
01:05:29,990 --> 01:05:28,480
delicate is that done on the robot level

1786
01:05:31,750 --> 01:05:30,000
does that evaluate it or does the human

1787
01:05:33,349 --> 01:05:31,760
operator control how much power it puts

1788
01:05:36,950 --> 01:05:33,359

into its motion so something like a

1789
01:05:39,190 --> 01:05:36,960
button push is um it's actually not the

1790
01:05:40,950 --> 01:05:39,200
hand it's there's a sensor that senses

1791
01:05:43,270 --> 01:05:40,960
force that's behind the hand sort of at

1792
01:05:44,870 --> 01:05:43,280
the wrist and so if you wanted to tell

1793
01:05:46,549 --> 01:05:44,880
whether or not you're pushing the button

1794
01:05:49,109 --> 01:05:46,559
you'd be looking at that particular

1795
01:05:51,190 --> 01:05:49,119
sensor to tell how hard you're pushing

1796
01:05:52,710 --> 01:05:51,200
some of the other the bits about

1797
01:05:54,230 --> 01:05:52,720
grabbing stuff

1798
01:05:57,510 --> 01:05:54,240
at this point the hand doesn't really

1799
01:05:59,990 --> 01:05:57,520
have the ability to a sense of touch or

1800
01:06:01,829 --> 01:06:00,000
even how hard it's grabbing things so if

1801
01:06:04,230 --> 01:06:01,839
it's not robust like if we tried to pick

1802
01:06:06,630 --> 01:06:04,240
up an egg with this it would just crush

1803
01:06:08,789 --> 01:06:06,640
it um so we try to pick up on things

1804
01:06:10,630 --> 01:06:08,799
that are relatively robust in themselves

1805
01:06:13,109 --> 01:06:10,640
like the drill is a very you know it's

1806
01:06:16,069 --> 01:06:13,119
designed for taking a lot of of abuse

1807
01:06:16,829 --> 01:06:16,079
and and we abuse it

1808
01:06:18,549 --> 01:06:16,839
thank

1809
01:06:21,589 --> 01:06:18,559
you

1810
01:06:23,349 --> 01:06:21,599
uh how simple are the controls for the

1811
01:06:25,109 --> 01:06:23,359
robot to use

1812
01:06:28,470 --> 01:06:25,119
simple

1813
01:06:30,870 --> 01:06:28,480

i'd say well i guess uh actually so i

1814
01:06:33,349 --> 01:06:30,880
would answer they're really simple but

1815
01:06:35,670 --> 01:06:33,359
um relative to what they do and you saw

1816
01:06:37,670 --> 01:06:35,680
the the user interface that we were

1817
01:06:39,430 --> 01:06:37,680
uh that we had so it showed the for

1818
01:06:42,789 --> 01:06:39,440
instance the valves the picture of the

1819
01:06:45,589 --> 01:06:42,799
valves and the the user flew in

1820
01:06:47,430 --> 01:06:45,599
a a valve on top of that and then said

1821
01:06:50,470 --> 01:06:47,440
you know execute this behavior that's

1822
01:06:53,510 --> 01:06:50,480
the simplest version and that as long as

1823
01:06:54,789 --> 01:06:53,520
it's within those sets of of behaviors

1824
01:06:57,829 --> 01:06:54,799
you can actually get that down and we

1825
01:06:59,029 --> 01:06:57,839
have to to running on a little robust

1826
01:07:01,910 --> 01:06:59,039
tablet

1827
01:07:04,309 --> 01:07:01,920
that that you could you know basically

1828
01:07:05,510 --> 01:07:04,319
for very simple tasks you that's all you

1829
01:07:07,109 --> 01:07:05,520
really need

1830
01:07:08,870 --> 01:07:07,119
for the stuff that we do

1831
01:07:12,069 --> 01:07:08,880
you know you can go all the way down

1832
01:07:14,150 --> 01:07:12,079
into the uh the lowest levels of of the

1833
01:07:16,470 --> 01:07:14,160
the system and actually get every joint

1834
01:07:17,910 --> 01:07:16,480
to do what you want it to

1835
01:07:19,349 --> 01:07:17,920
but that's a very

1836
01:07:20,470 --> 01:07:19,359
time inefficient way of getting things

1837
01:07:24,230 --> 01:07:20,480
done

1838
01:07:26,069 --> 01:07:24,240

and um how long and uh what is how what

1839
01:07:27,270 --> 01:07:26,079
is the range

1840
01:07:28,710 --> 01:07:27,280
of

1841
01:07:30,630 --> 01:07:28,720
distance that you can communicate with

1842
01:07:33,829 --> 01:07:30,640
the robot and how long

1843
01:07:37,430 --> 01:07:33,839
does the robot run with power source

1844
01:07:39,990 --> 01:07:37,440
so the runs on normal wi-fi so i think

1845
01:07:41,670 --> 01:07:40,000
we probably have you know a couple

1846
01:07:43,349 --> 01:07:41,680
hundred yards at most

1847
01:07:45,190 --> 01:07:43,359
that you know at the way it's set up

1848
01:07:47,349 --> 01:07:45,200
right now you'd actually have to you

1849
01:07:49,270 --> 01:07:47,359
know to to make this a truly fieldable

1850
01:07:51,109 --> 01:07:49,280
system depending on where you're going

1851
01:07:54,710 --> 01:07:51,119
to apply it like if you wanted it to go

1852
01:07:57,029 --> 01:07:54,720
into a fukushima like scenario you're

1853
01:07:59,589 --> 01:07:57,039
probably going to use different comm

1854
01:08:01,589 --> 01:07:59,599
gear the com gear that we have is is

1855
01:08:04,150 --> 01:08:01,599
that dictated by darpa for the for the

1856
01:08:05,990 --> 01:08:04,160
trials or for the finals so

1857
01:08:07,750 --> 01:08:06,000
um it's sort of limited that normal

1858
01:08:08,710 --> 01:08:07,760
wi-fi kind of uh

1859
01:08:11,029 --> 01:08:08,720
system

1860
01:08:12,069 --> 01:08:11,039
so then how would you communicate it

1861
01:08:14,630 --> 01:08:12,079
when

1862
01:08:16,550 --> 01:08:14,640
you said like for example the uh cave in

1863
01:08:18,630 --> 01:08:16,560

you the caves in new mexico like

1864
01:08:21,349 --> 01:08:18,640
wouldn't that block the water that is a

1865
01:08:23,349 --> 01:08:21,359
very good question um so you know we use

1866
01:08:25,430 --> 01:08:23,359
those caves as a stand-in for the caves

1867
01:08:26,870 --> 01:08:25,440
that we believe to be on mars

1868
01:08:28,309 --> 01:08:26,880
and if we get down to that then we're

1869
01:08:29,829 --> 01:08:28,319
going to use some very sophisticated

1870
01:08:31,189 --> 01:08:29,839
comm technology including things like

1871
01:08:34,229 --> 01:08:31,199
optical com

1872
01:08:37,189 --> 01:08:34,239
with repeater stations for instance

1873
01:08:38,950 --> 01:08:37,199
and how long can you run the robot

1874
01:08:40,470 --> 01:08:38,960
so robosimian as i said it's got this

1875
01:08:42,229 --> 01:08:40,480
two kilowatt hour battery we don't

1876
01:08:44,070 --> 01:08:42,239
actually know

1877
01:08:46,709 --> 01:08:44,080
how long we can run it depending on what

1878
01:08:48,870 --> 01:08:46,719
you're doing um

1879
01:08:51,269 --> 01:08:48,880
the

1880
01:08:53,349 --> 01:08:51,279
we don't you you know so

1881
01:08:55,990 --> 01:08:53,359
i'll answer the question this way we're

1882
01:08:57,990 --> 01:08:56,000
only allowed an hour to do all of the

1883
01:09:00,789 --> 01:08:58,000
finals and we're pretty sure that we

1884
01:09:03,110 --> 01:09:00,799
can't run at two kilowatts so we know

1885
01:09:05,430 --> 01:09:03,120
that we can run at least an hour

1886
01:09:07,030 --> 01:09:05,440
the the in practical application that

1887
01:09:08,709 --> 01:09:07,040
two kilowatt hours if you're careful

1888
01:09:10,070 --> 01:09:08,719

about what you're doing and the robot

1889
01:09:13,030 --> 01:09:10,080
spends a lot of time sitting around

1890
01:09:15,829 --> 01:09:13,040
which you know is a very likely event uh

1891
01:09:18,309 --> 01:09:15,839
then its actual time of operation could

1892
01:09:19,910 --> 01:09:18,319
be eight to ten hours

1893
01:09:22,950 --> 01:09:19,920
so but that's mostly predicated on the

1894
01:09:24,709 --> 01:09:22,960
fact that sitting around a lot

1895
01:09:25,510 --> 01:09:24,719
i think we oh yeah there we go we've got

1896
01:09:29,990 --> 01:09:25,520
some

1897
01:09:33,430 --> 01:09:32,229
all right

1898
01:09:35,510 --> 01:09:33,440
so these are

1899
01:09:37,269 --> 01:09:35,520
sent in

1900
01:09:38,309 --> 01:09:37,279
so coolbot7

1901
01:09:42,229 --> 01:09:38,319
asks

1902
01:09:43,430 --> 01:09:42,239
autonomously versus those that are human

1903
01:09:44,709 --> 01:09:43,440
controlled

1904
01:09:47,189 --> 01:09:44,719
so

1905
01:09:48,630 --> 01:09:47,199
robosemen actually uses

1906
01:09:51,030 --> 01:09:48,640
a system that's very similar to the way

1907
01:09:53,590 --> 01:09:51,040
we deal with the rovers on mars and we

1908
01:09:55,990 --> 01:09:53,600
call it supervised autonomy

1909
01:09:58,390 --> 01:09:56,000
and as i've been talking about behaviors

1910
01:10:01,350 --> 01:09:58,400
basically

1911
01:10:03,910 --> 01:10:01,360
every behavior is autonomous in itself

1912
01:10:05,350 --> 01:10:03,920
so it takes input from the operator and

1913
01:10:07,990 --> 01:10:05,360

then

1914
01:10:09,669 --> 01:10:08,000
it executes that particular behavior

1915
01:10:11,510 --> 01:10:09,679
autonomously

1916
01:10:13,030 --> 01:10:11,520
including things like noticing air

1917
01:10:15,510 --> 01:10:13,040
conditions and stopping itself and

1918
01:10:16,870 --> 01:10:15,520
calling home so

1919
01:10:18,310 --> 01:10:16,880
within a particular behavior it's

1920
01:10:19,830 --> 01:10:18,320
autonomous

1921
01:10:22,550 --> 01:10:19,840
the the way that those behaviors get

1922
01:10:25,030 --> 01:10:22,560
linked together are um the supervised

1923
01:10:27,910 --> 01:10:25,040
aspect of it so those are all built by

1924
01:10:28,709 --> 01:10:27,920
uh built up by the the human operators

1925
01:10:31,430 --> 01:10:28,719
so

1926
01:10:34,149 --> 01:10:31,440
hopefully that answered that one

1927
01:10:36,070 --> 01:10:34,159
uh daniel asks how durable is robosimian

1928
01:10:37,350 --> 01:10:36,080
what temperatures can it withstand water

1929
01:10:38,870 --> 01:10:37,360
flooding

1930
01:10:40,470 --> 01:10:38,880
so

1931
01:10:42,630 --> 01:10:40,480
it's pretty durable

1932
01:10:45,030 --> 01:10:42,640
a little known fact we've actually

1933
01:10:47,350 --> 01:10:45,040
rolled it once

1934
01:10:48,310 --> 01:10:47,360
it was fine it's all good

1935
01:10:49,270 --> 01:10:48,320
um

1936
01:10:51,430 --> 01:10:49,280
so

1937
01:10:52,390 --> 01:10:51,440
uh we're we know it's at least that

1938
01:10:55,430 --> 01:10:52,400

durable

1939
01:10:57,750 --> 01:10:55,440
um and it really is you can see

1940
01:10:59,669 --> 01:10:57,760
the battle scars on it it's it's uh

1941
01:11:01,430 --> 01:10:59,679
i've challenged everyone to see if they

1942
01:11:03,510 --> 01:11:01,440
could break it um

1943
01:11:05,910 --> 01:11:03,520
and we haven't yet although we've bent

1944
01:11:08,229 --> 01:11:05,920
it just to touch

1945
01:11:09,990 --> 01:11:08,239
so it's physically very robust and

1946
01:11:11,830 --> 01:11:10,000
designed that way on purpose one of the

1947
01:11:12,950 --> 01:11:11,840
nice things about not having a head and

1948
01:11:14,950 --> 01:11:12,960
neck is that you don't have a head and

1949
01:11:17,910 --> 01:11:14,960
neck to break off

1950
01:11:19,030 --> 01:11:17,920
so that's one of the advantages of that

1951
01:11:20,310 --> 01:11:19,040
the temperatures are going to withstand

1952
01:11:23,270 --> 01:11:20,320
so these are normal commercial

1953
01:11:25,590 --> 01:11:23,280
electronics so we're talking about

1954
01:11:28,310 --> 01:11:25,600
you know somewhere below freezing to

1955
01:11:31,510 --> 01:11:28,320
somewhere warmer than comfortable

1956
01:11:35,350 --> 01:11:31,520
temperatures uh for humans so

1957
01:11:36,870 --> 01:11:35,360
yeah 120 c or so and actually the robot

1958
01:11:38,390 --> 01:11:36,880
didn't doing its job there's a lot of

1959
01:11:41,990 --> 01:11:38,400
waste heat so it actually heats itself

1960
01:11:46,470 --> 01:11:44,470
water and flooding so this version is

1961
01:11:49,590 --> 01:11:46,480
not water sealed at all

1962
01:11:51,830 --> 01:11:49,600
we are working on elements that we

1963
01:11:53,590 --> 01:11:51,840

the system we're calling aqua simian

1964
01:11:55,110 --> 01:11:53,600
and for those that are quick on the draw

1965
01:11:58,790 --> 01:11:55,120
you'll notice that that's just a really

1966
01:12:03,750 --> 01:12:01,510
so aquasimian is in fact designed to be

1967
01:12:06,149 --> 01:12:03,760
fully immersible and in fact

1968
01:12:09,189 --> 01:12:06,159
the design is probably good to about 50

1969
01:12:11,430 --> 01:12:09,199
meters or so so we're hoping to bring

1970
01:12:15,030 --> 01:12:11,440
that design along as fast as we can a

1971
01:12:16,229 --> 01:12:15,040
fieldable system uh even terrestrial

1972
01:12:18,550 --> 01:12:16,239
would have to be

1973
01:12:20,070 --> 01:12:18,560
certainly weather sealed so call it a

1974
01:12:22,550 --> 01:12:20,080
good camera

1975
01:12:25,430 --> 01:12:22,560
level of ceiling to keep it the dust and

1976
01:12:29,430 --> 01:12:27,910
uh aldo navarro asks

1977
01:12:31,510 --> 01:12:29,440
is the last one

1978
01:12:33,270 --> 01:12:31,520
is ross able to work in space like

1979
01:12:34,070 --> 01:12:33,280
outside the iss to repair or perform

1980
01:12:37,510 --> 01:12:34,080
work

1981
01:12:39,590 --> 01:12:37,520
not as it is so um again these are

1982
01:12:41,669 --> 01:12:39,600
commercial electronics uh when we

1983
01:12:44,229 --> 01:12:41,679
actually build systems for space it's a

1984
01:12:45,750 --> 01:12:44,239
whole different set of bits and pieces

1985
01:12:48,229 --> 01:12:45,760
that go into it

1986
01:12:50,470 --> 01:12:48,239
that's what turns these research robots

1987
01:12:53,590 --> 01:12:50,480
into flight robots is

1988
01:12:57,350 --> 01:12:53,600

going through and working out all of the

1989
01:12:58,790 --> 01:12:57,360
issues with vacuum and cold and hot

1990
01:13:01,030 --> 01:12:58,800
and replacing the components as

1991
01:13:03,189 --> 01:13:01,040
necessary to do that so as is there's

1992
01:13:04,870 --> 01:13:03,199
very little of

1993
01:13:07,350 --> 01:13:04,880
at the individual piece part level of a

1994
01:13:09,669 --> 01:13:07,360
robosimian that could be translated

1995
01:13:11,430 --> 01:13:09,679
directly to a flight

1996
01:13:14,229 --> 01:13:11,440
application

1997
01:13:16,310 --> 01:13:14,239
now the concept of the robot

1998
01:13:17,910 --> 01:13:16,320
is very much something that we would

1999
01:13:20,310 --> 01:13:17,920
like to see in space

2000
01:13:22,070 --> 01:13:20,320
the the iris uh

2001
01:13:24,630 --> 01:13:22,080
concept that i was showing you that

2002
01:13:28,550 --> 01:13:24,640
would be uh for inspection is

2003
01:13:30,229 --> 01:13:28,560
effectively very similar to robo simeon

2004
01:13:32,790 --> 01:13:30,239
the the robot that we use for testing

2005
01:13:37,110 --> 01:13:32,800
here on earth called lemur for the iris

2006
01:13:38,870 --> 01:13:37,120
project is basically a small robosimian

2007
01:13:40,790 --> 01:13:38,880
it's actually bodies about yea big and

2008
01:13:42,470 --> 01:13:40,800
the limbs are about yea long but

2009
01:13:45,669 --> 01:13:42,480
otherwise

2010
01:13:48,229 --> 01:13:45,679
from a squinty point of view

2011
01:13:49,669 --> 01:13:48,239
a very similar system so we we very much

2012
01:13:51,590 --> 01:13:49,679
hope to be able to put that kind of

2013
01:13:53,350 --> 01:13:51,600

thing on the outside of long-duration

2014
01:13:55,830 --> 01:13:53,360
spacecraft in particular for inspection

2015
01:13:57,350 --> 01:13:55,840
and maintenance at some point or another

2016
01:13:59,189 --> 01:13:57,360
so that's the last question i have does

2017
01:14:01,189 --> 01:13:59,199
anybody else have any more questions

2018
01:14:04,790 --> 01:14:01,199
they'd like to ask and

2019
01:14:08,790 --> 01:14:07,110
would it be able to hear or like send

2020
01:14:10,070 --> 01:14:08,800
audio to the

2021
01:14:11,590 --> 01:14:10,080
operator

2022
01:14:13,910 --> 01:14:11,600
good question

2023
01:14:15,510 --> 01:14:13,920
uh that would be spiffy and we actually

2024
01:14:17,110 --> 01:14:15,520
that was an intention

2025
01:14:19,189 --> 01:14:17,120
one of our intentions when we first laid

2026
01:14:20,229 --> 01:14:19,199
out the design it's not something we've

2027
01:14:21,270 --> 01:14:20,239
done

2028
01:14:22,070 --> 01:14:21,280
to date

2029
01:14:23,910 --> 01:14:22,080
but

2030
01:14:25,110 --> 01:14:23,920
absolutely you would want to be able to

2031
01:14:27,350 --> 01:14:25,120
put years

2032
01:14:29,590 --> 01:14:27,360
in the system if

2033
01:14:31,430 --> 01:14:29,600
not for the robot to use as information

2034
01:14:32,870 --> 01:14:31,440
but it would be a really great cue for

2035
01:14:34,070 --> 01:14:32,880
humans you know humans take in

2036
01:14:36,229 --> 01:14:34,080
information in all sorts of different

2037
01:14:37,910 --> 01:14:36,239
ways and the more channels of

2038
01:14:39,830 --> 01:14:37,920

information that we can provide the

2039
01:14:41,430 --> 01:14:39,840
operator the better they're

2040
01:14:44,070 --> 01:14:41,440
understanding the situation the robot's

2041
01:14:46,229 --> 01:14:44,080
in is going to be so

2042
01:14:47,910 --> 01:14:46,239
having some sort of audio pickup would

2043
01:14:49,910 --> 01:14:47,920
be would be fantastic because it could

2044
01:14:51,990 --> 01:14:49,920
be just as simple as i'm looking for a

2045
01:14:53,350 --> 01:14:52,000
leak i need to listen for it it's one of

2046
01:14:55,669 --> 01:14:53,360
the you know very basic things a human

2047
01:14:58,149 --> 01:14:55,679
would do so not putting some sort of

2048
01:14:59,910 --> 01:14:58,159
system like that on an actual fielded

2049
01:15:03,030 --> 01:14:59,920
robot like robo simulator would be

2050
01:15:16,630 --> 01:15:05,030
cool well if there's nothing else thank