CS 5 finale

Looking back! Evals, Ideas

Looking ahead? Options…

CS 5: Final lecture

now!

I'll be back…

but that's my line!

CS 5, on the verge of *termination*

CS 5 Final Projects

due this Fri. eve @ 8 (Sat. w/ Euro)

LAC hrs Fri. & tutoring hours through then…

CS 5 Review Session

7-8 pm Sun., 12/11 in Shanahan B460

warning: only 100 seats!

- to go over the practice exam problems + q'ns

CS 5 Final Exam

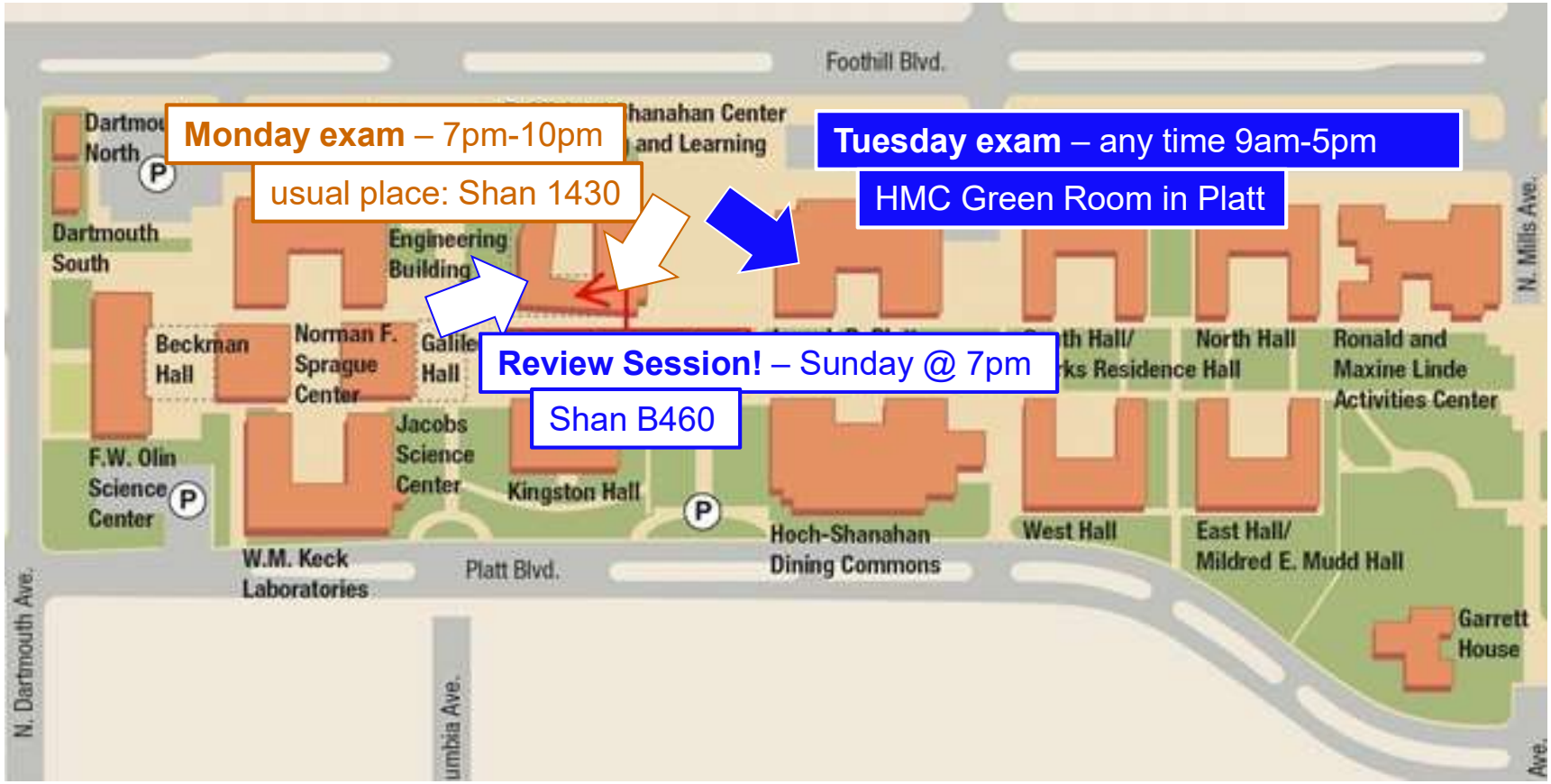
comprehensive – ***but not this week's material***

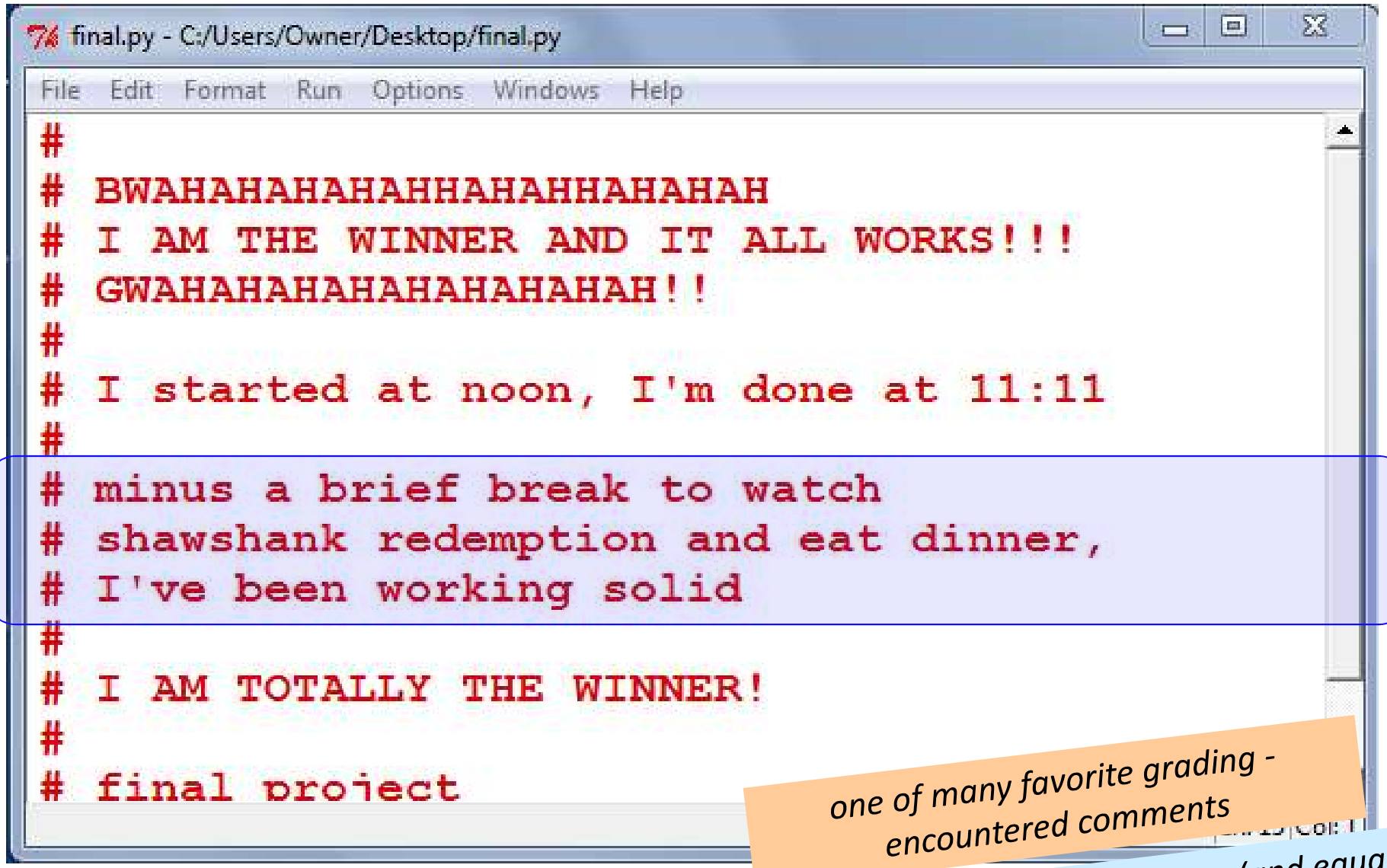
7pm Mon. 12/12 in Shan 1430 – this room

Accommodations nearby rooms (next door)

ALL DAY 9am-5pm Tue. 12/13 in the Green Room (in the HMC Platt Building)

CS 5's map of final events...

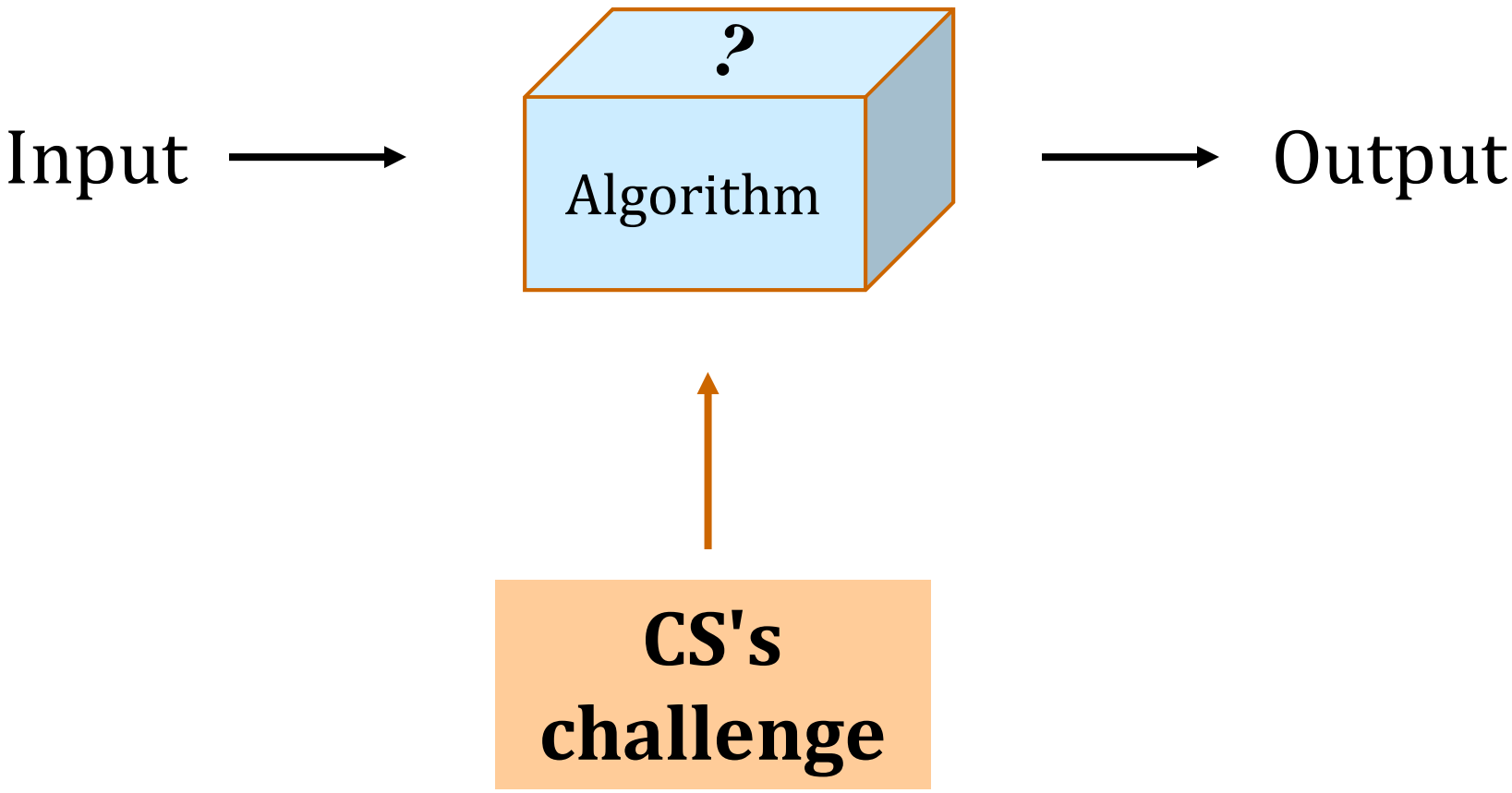




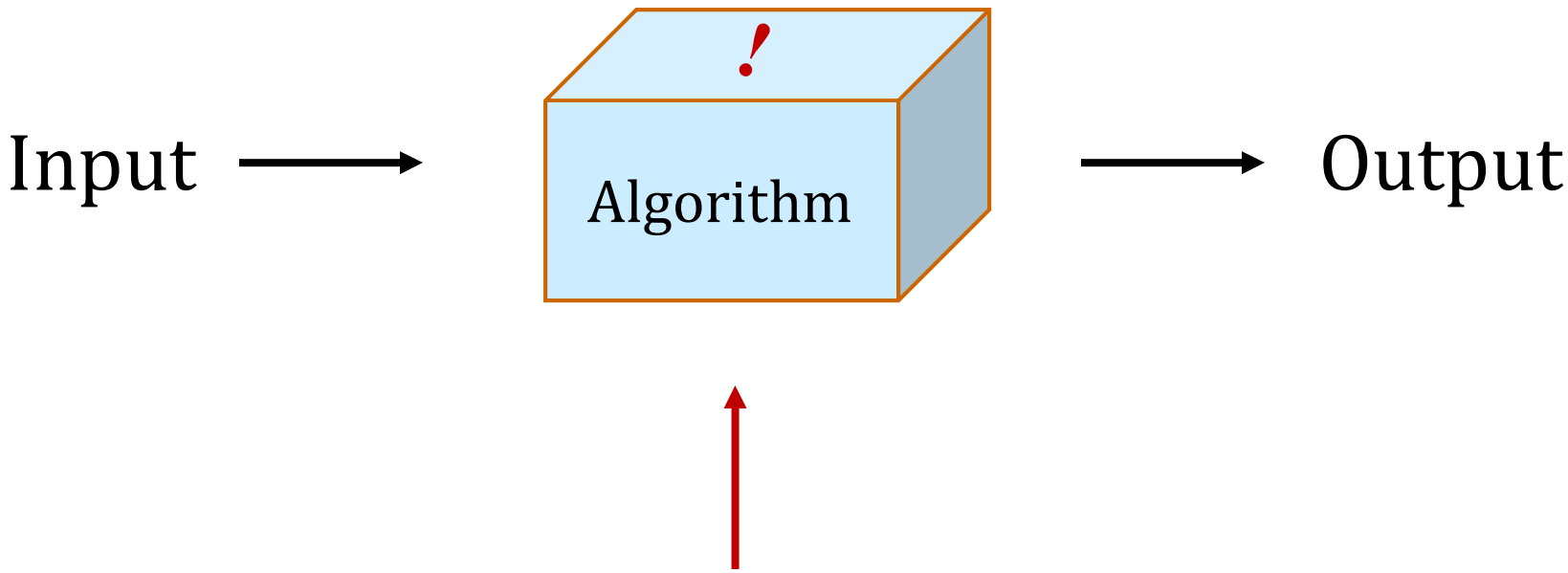
one of many favorite grading - encountered comments

may you find equal success (and equal movie-watching time!)

The CS view of the world...



Uncomputable functions



Sometimes an algorithm simply does *not* exist…

more precisely: every possible algorithm contains bugs!

Haltchecking is uncomputable.

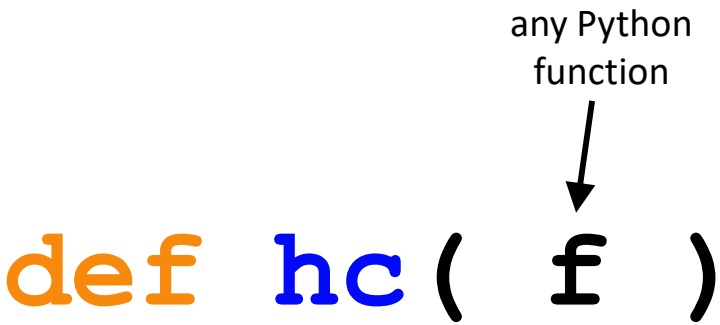
Halt Checking

`hc( f )`

~ returns whether **`f()`** halts or not

`hc` *always* has a bug!

Haltchecking is uncomputable.



It is <u>impossible</u> to write a (bug-free) function **`hc(f)`** that determines if a function **`f`** halts when run:

(1) **`hc(f)`** returns **`True`** if **`f()`** halts and

(2) **`hc(f)`** returns **`False`** if **`f()`** loops infinitely

Suppose `hc(f)` worked for all `f`

Create this `BFF`:

```
def BFF():
    if hc(BFF) == True:
        while 1+1==2: print 'Ha!'
    else:
        return  # halt!
```

Is `hc(BFF) == True` ?

Is `hc(BFF) == False`?

`hc` *always* has a bug

Proven!

And this is important because …

∞ loops are *undetectable*

some are detectable, but ***some*** are not
– and there's no way to know!

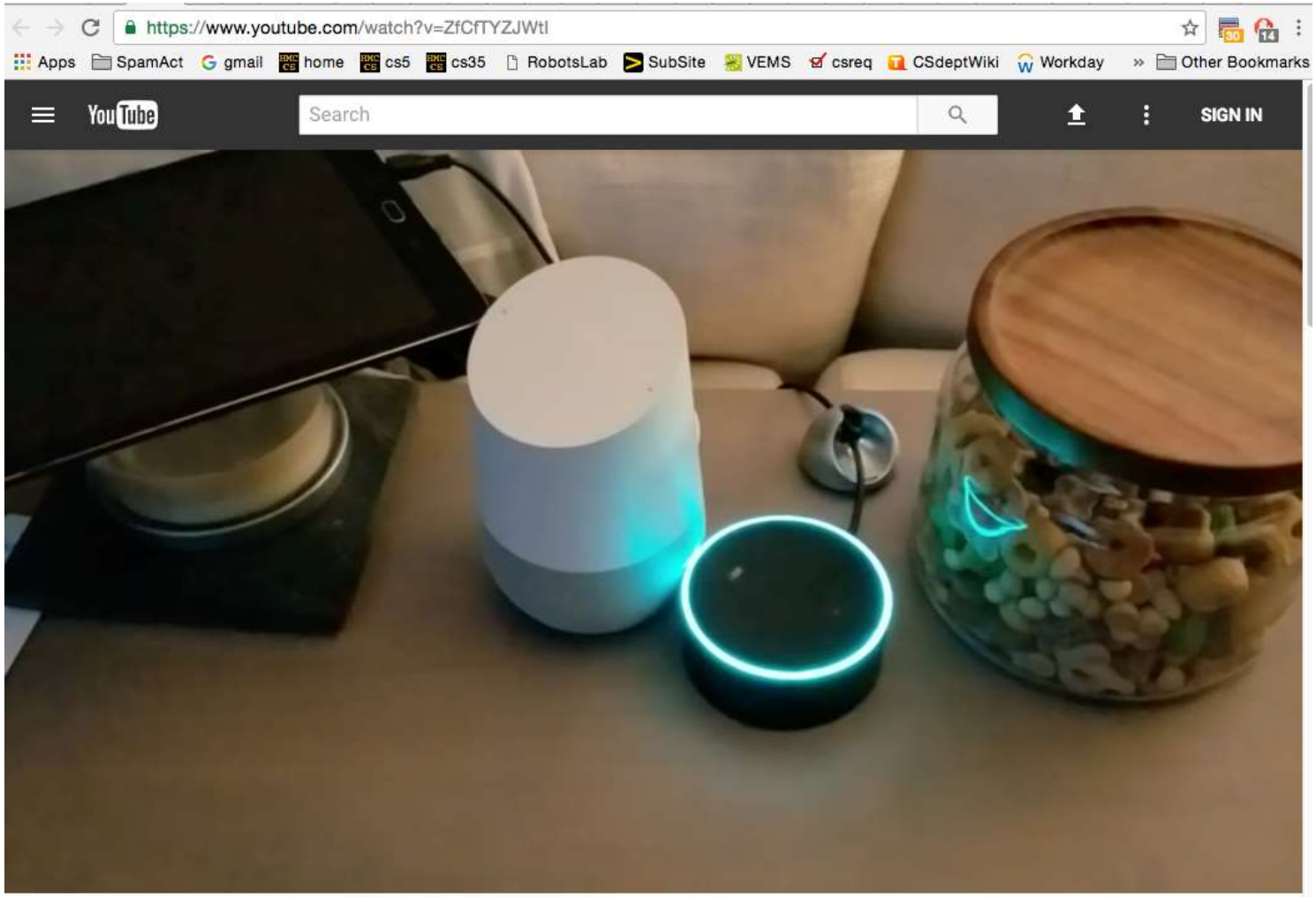
bugs are *inevitable*

infinite loops are just ***one*** type of bug…
In general, they're <u>all</u> undetectable

programming is ***not automatable***…

not *<u>perfect</u>* programming, at least

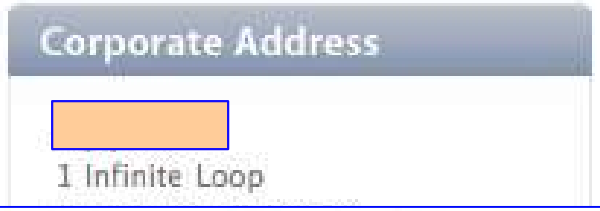
it's why CSers *celebrate* infinite loops !



https://www.youtube.com/watch?v=ZfCfTYZJWtI

Echo/Google Home infinite loop

659,592 views



Halting problem

From Wikipedia, the free encyclopedia

In computability theory, the **halting problem** can be stated as follows: Given a description of a computer program, decide whether the program finishes running or continues to run forever. This is equivalent to the problem of deciding, given a program and an input, whether the program will eventually halt when run with that input, or will run forever.

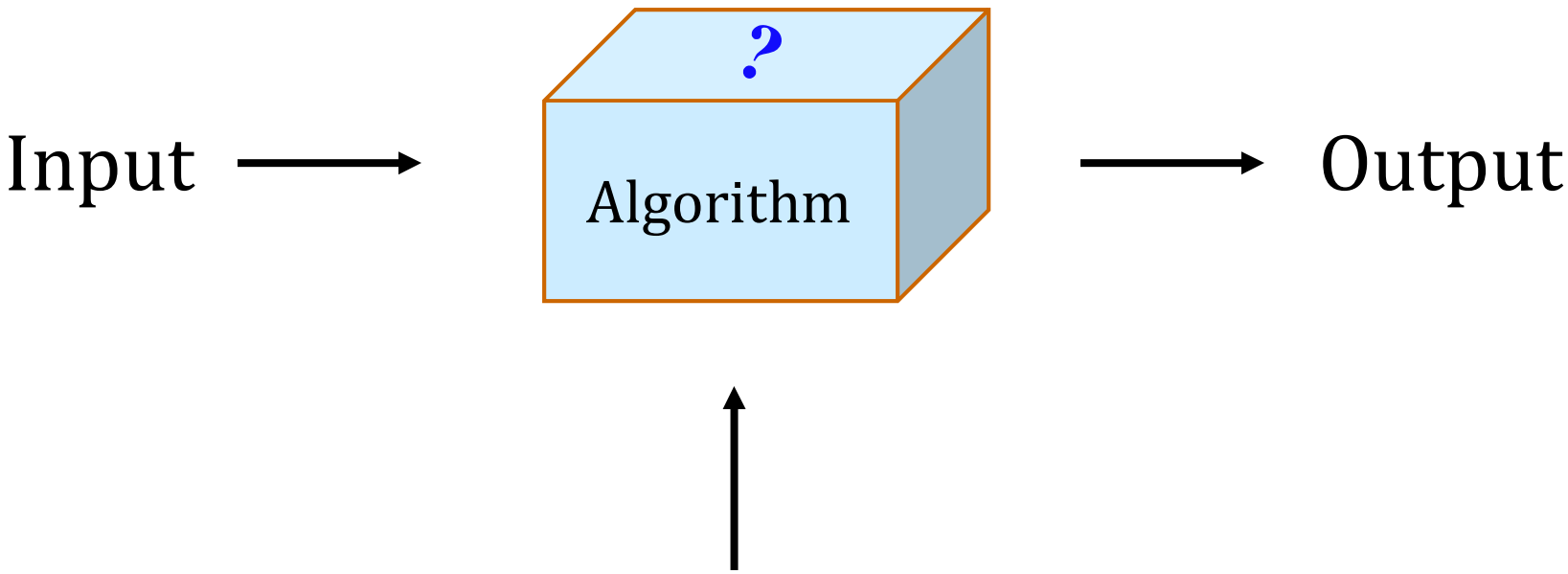
Alan Turing proved in 1936 that a general algorithm to solve the halting problem for *all* possible program-input pairs cannot exist. A key part of the proof was a mathematical definition of a computer and program, what became known as a Turing machine; the

original iPhone
icon for Maps

CS tourism !

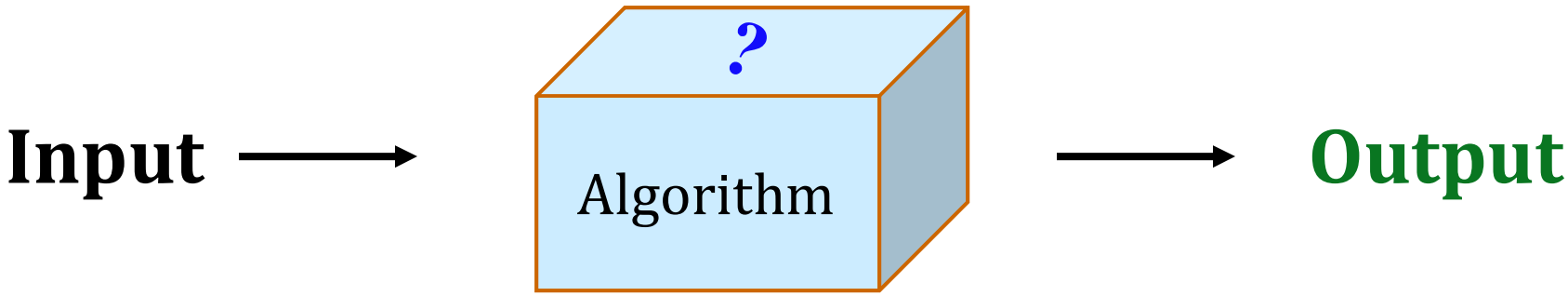

More CS
tourism…
(Google)
42
Google
Building 42
Lobby

Meaningful functions?



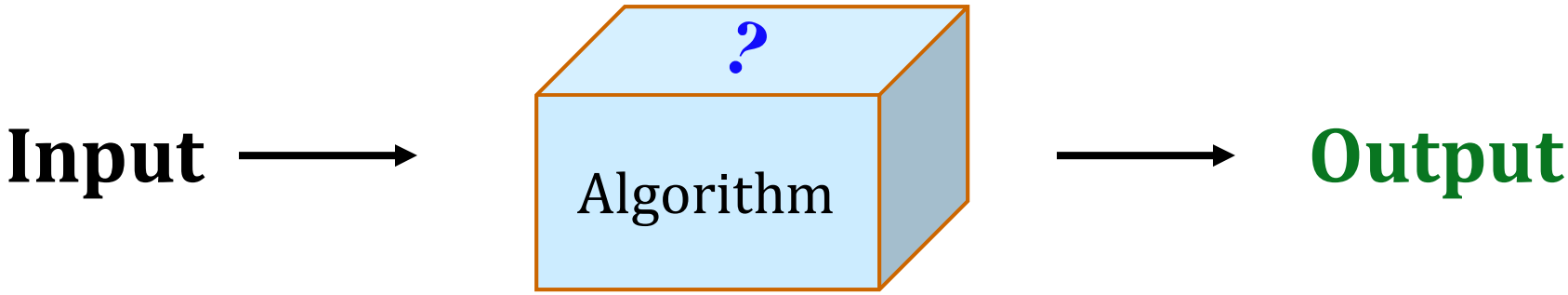
but nearly all ***meaningful***
functions ***are*** computable…

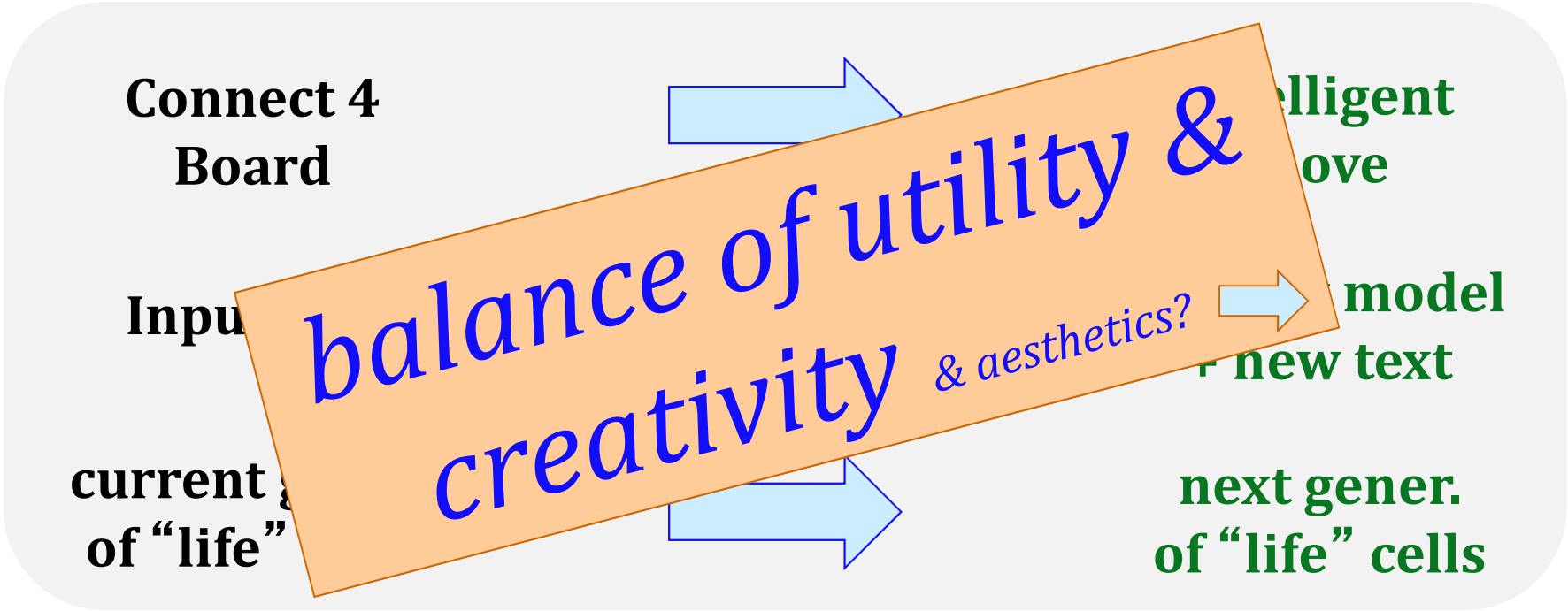
CS 5's examples…



Connect 4 Board	→	**intelligent move**
Input text	→	**Markov model + new text**
current gener. of "life" cells	→	**next gener. of "life" cells**

CS 5's examples…






Mandelbrot Vistas!

"Science without religion is lame, religion without science is blind."
"Two things are infinite: the universe and human stupidity; and I'm not sure about the universe."
"Duct tape is like the force, it has a light side, a dark side, and it holds the world together"
"If you die in an elevator, be sure to push the Up button."
"All generalizations are false, including this one."
"Clearly you've never been to Singapore!"
"Luke, I am your father."
"To be, or not to be."
"You shall not pass!"
(… all with authors …)

INPUTS

Markov-generated wisdom!

OUTPUTS

"Science without religion is lame, religion without science is blind."
"Two things are infinite: the universe and human stupidity; and I'm not sure about the universe."
"Duct tape is like the force, it has a light side, a dark side, and it holds the world together"
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"Clearly you've never been to Singapore!"
"Luke, I am your father."
"To be, or not to be."
"You shall not pass!"
(… all with authors …)

INPUTS

Markov-generated wisdom!

OUTPUTS

"I have a dream! Duct tape is written on. Luke, I am your thoughts and what lies within us."
---- Audrey Rooney

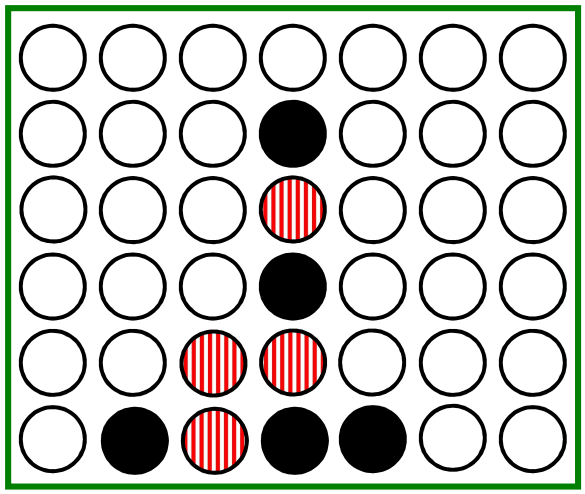
"Your work is lame, religion is lame, religion is nearly the Up button."
---- Abraham Marx

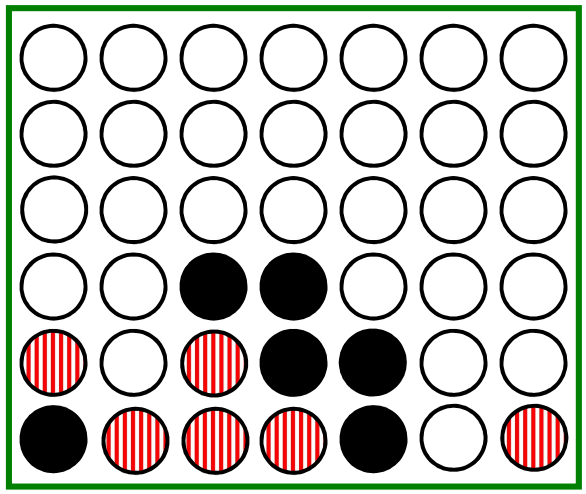
"Two things are false, including this one."
---- Captain_Jack Truman

Connect-4 *tiebreaking*…

`scoreBoard` would give each of these 50.0

but which board is ***really*** better for black?





Ex. Cr.: write a **`scoreBoard4Tourney`** f'n.

taken ***beyond*** the extreme…

CMC
aibrahim.py
aliu.py
bblackstone.py
clu.py
crlee.py
elarsen.py
hpinson.py
jseacat.py
kkapur.py
lgiurata.py
mmuller.py
mmulligan.py
nbehrman.py
nkanade.py
rmoore.py
rsalazar.py
rzimmerman.py
smarkowitz.py

Pomona
abi.py
gbarlow.py
mhahn.py
obell.py
yzhao.py

Pitzer
ltran.py
syasunaga.py

Scripps
ahembrough.py
ewalter.py
jliao.py
yyang.py

H.S.
nlibeskind.py
pdonnelly.py

HMC
aschulze.py
cmcelroy.py
bbrown.py
kyamada.py
lstevenson.py
mguillory.py
nsmith.py
vivojha.py

C4 Tourney ~ *23 entries in fall 2016!*

Wow!

thanks, everyone!

will run this evening…

CMC
aibrahim.py
aliu.py
bblackstone.py
clu.py
crlee.py
elarsen.py
hpinson.py
jseacat.py
kkapur.py
lgiurata.py
mmuller.py
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nbehrman.py
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rmoore.py
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bbrown.py
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lstevenson.py
mguillory.py
nsmith.py
vivojha.py

gbarlow vs. obell …

syasunaga:
(undefeated!)

…ey ~ 39 entries in fall 2015!

ahembrough:
(undefeated!)

nl_pd vs pd _nl:
(one entry!)

bbrown, lstevenson, kyamada

Finals: *cmcelroy*, lstevenson

cmcelroy, vivojha, mg_ns

Inspired by Chris Cecka…

Cris Cecka <ccecka@seas.harvard.edu> 10/24/14

to Zachary

Hi Prof Dodds!

Looks like it's been twelve years now (choke)... Glad to hear you're still doing this in class!

Cris Cecka

Lecturer, Research Scientist
Applied Computational Science

IACS HARVARD School of Engineering and Applied Sciences

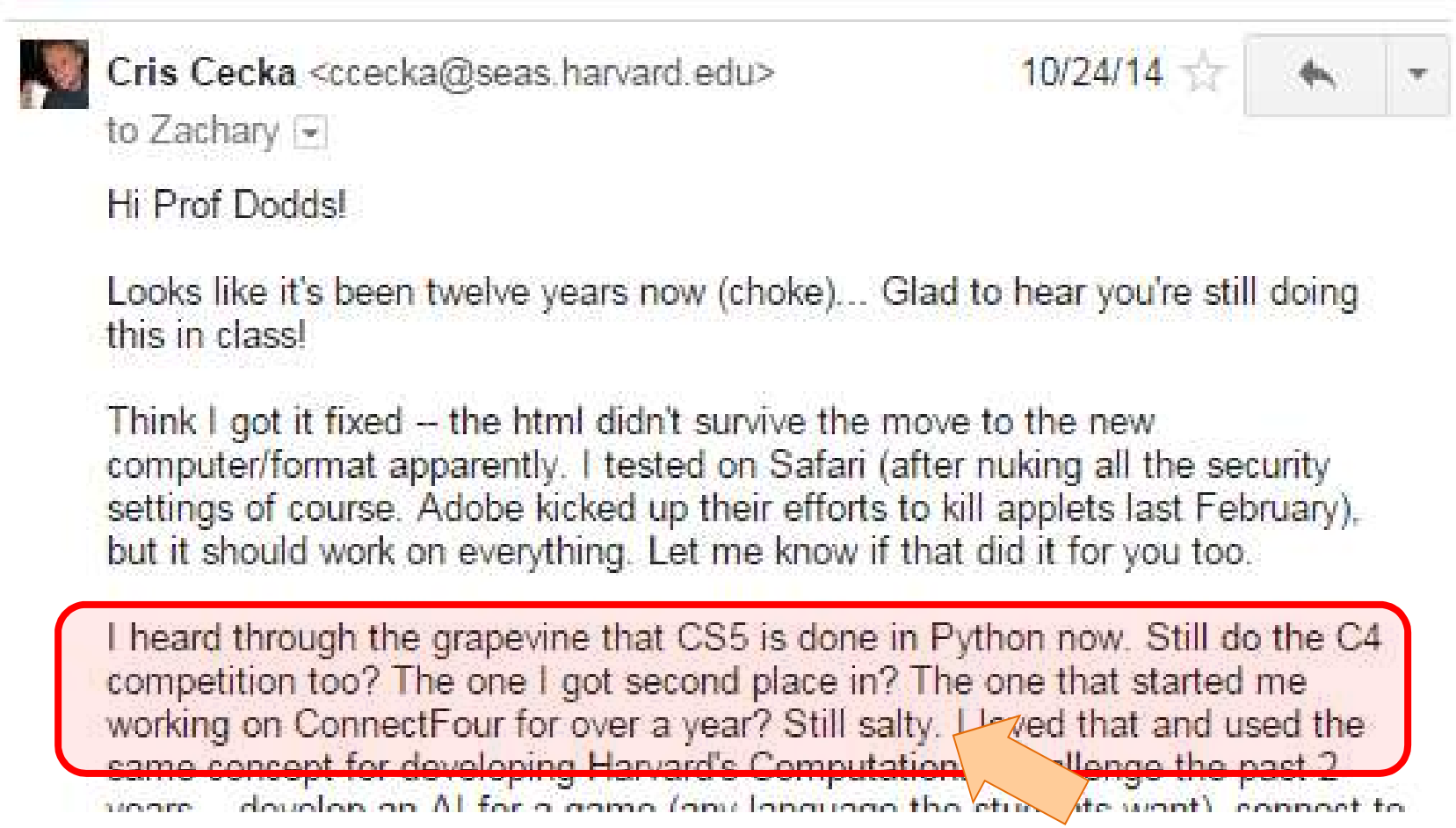
- About
- Research
- Projects
- Teaching
- CV
- Links&Notes
- Contact Me

Introduction

I am currently a Lecturer/Research Scientist in the new Institute for Applied Computational Science (IACS) at Harvard University. Previously, I was a graduate student in the Institute for Computational and Mathematical Engineering (ICME) at Stanford University with Eric Darve.

My research focuses on computational mathematics, particularly for interdisciplinary applications in science and engineering. I emphasize physical modeling and high performance computing, but am recently interested in mathematical and computational abstractions to produce efficient, library-quality scientific software. Specifically, I am interested in integral equation methods, structured dense matrices, and parallel algorithmic development.

This year's Cris Cecka award…



Cris Cecka <ccecka@seas.harvard.edu> 10/24/14

to Zachary

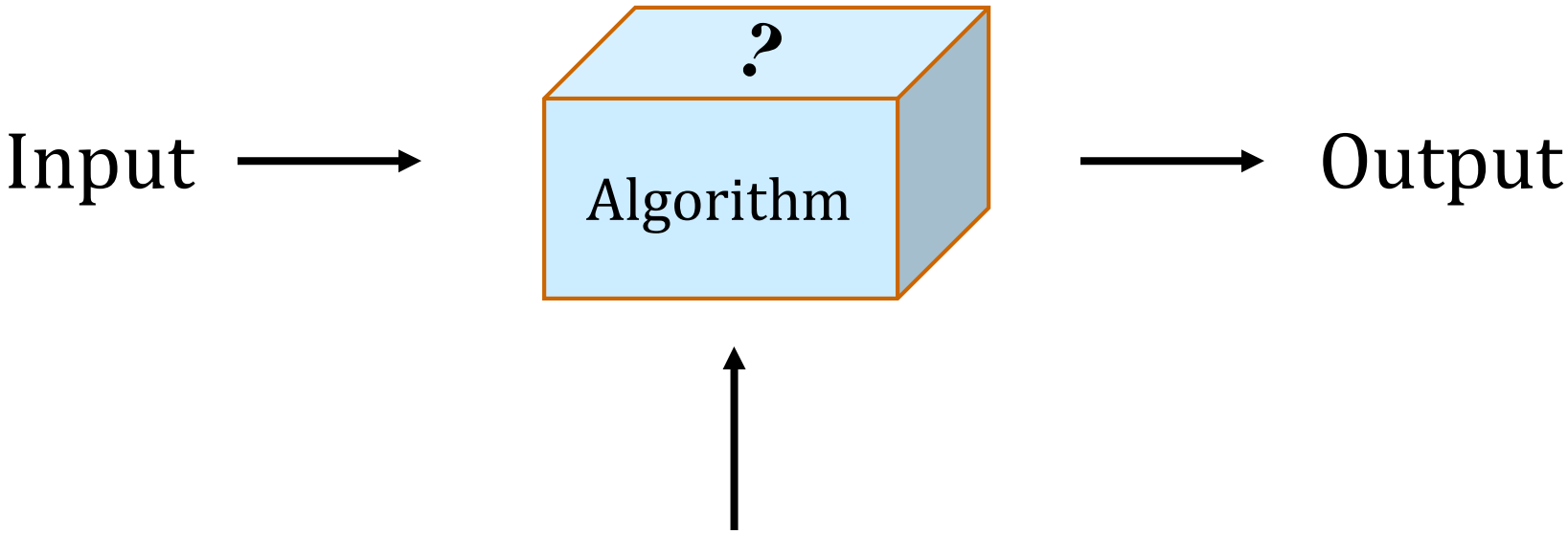
Hi Prof Dodds!

Looks like it's been twelve years now (choke)... Glad to hear you're still doing this in class!

Think I got it fixed -- the html didn't survive the move to the new computer/format apparently. I tested on Safari (after nuking all the security settings of course. Adobe kicked up their efforts to kill applets last February), but it should work on everything. Let me know if that did it for you too.

I heard through the grapevine that CS5 is done in Python now. Still do the C4 competition too? The one I got second place in? The one that started me working on ConnectFour for over a year? Still salty. I loved that and used the same concept for developing Harvard's Computation[illegible]llenge the past 2 years... develop an AI for a game (any language the stu[illegible]nts want), connect to

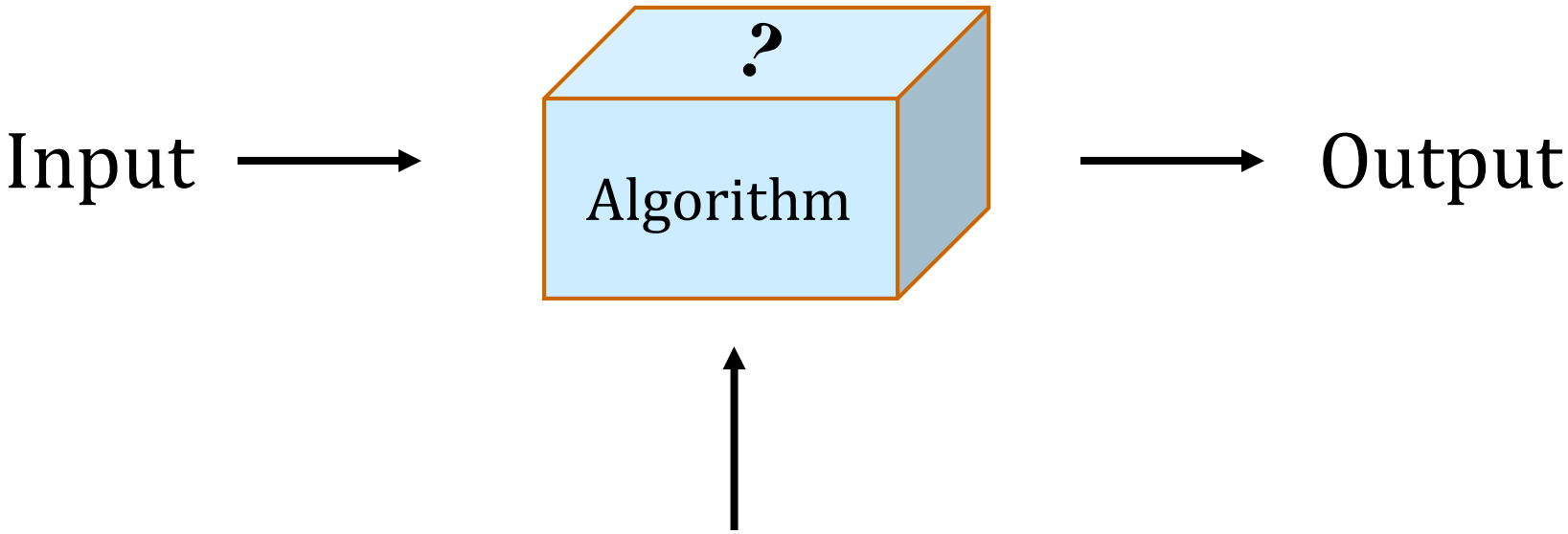
goes to…



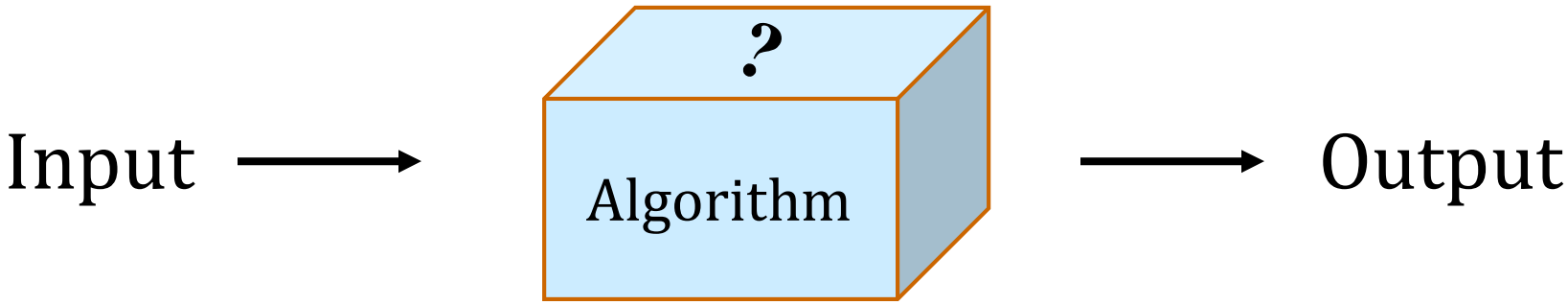
Fortunately, nearly all ***meaningful*** functions ***are*** computable…

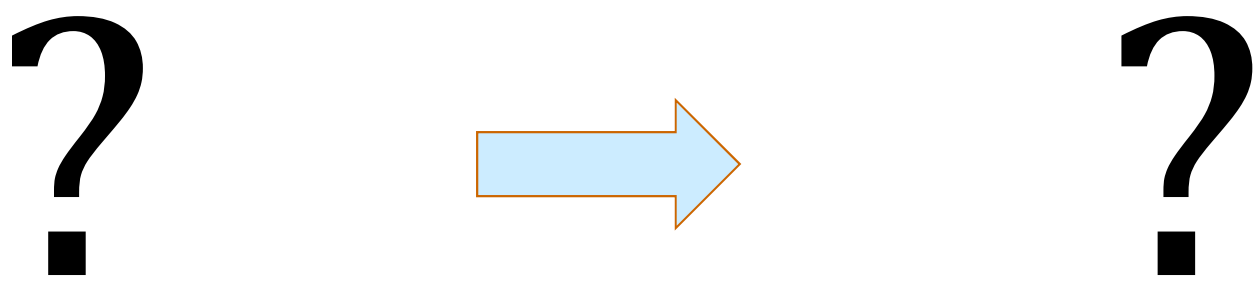
but this doesn't mean we know how to compute them (yet)!

for example …



the ***computer vision*** problem





computer vision: *what's* the *input* and *output*?

Input → ? Algorithm → Output

020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
047 109 107 118 107 115 110 120 120 124 120 128 124 132 131
047 125 130 130 122 121 117 142 131 133 134 141 149 144 135
051 139 143 139 147 134 149 069 127 144 139 144 150 161 149
054 136 161 148 147 158 055 052 034 030 158 156 165 163 156
043 144 165 159 154 171 224 191 047 030 171 165 175 164 163
025 161 174 172 167 049 200 193 112 028 120 169 173 177 173
011 091 101 105 177 039 078 060 041 026 073 102 167 208 121
011 091 094 066 094 033 199 184 139 024 060 094 125 152 134
009 068 072 072 065 031 151 171 075 028 035 072 083 109 063
013 068 074 059 057 037 161 129 062 028 035 071 072 078 056
012 042 063 055 072 033 020 067 031 022 027 082 070 073 060
011 037 064 094 091 026 025 080 066 026 023 071 070 080 060
011 060 077 082 037 023 024 147 140 038 023 037 043 076 037
013 049 076 059 032 028 174 197 182 060 021 021 121 101 062
013 059 111 072 020 078 200 211 182 061 069 059 043 086 106
007 053 057 092 023 105 189 230 210 084 034 021 017 033 091
011 061 072 018 027 054 069 068 062 023 045 011 016 042 044
014 041 047 025 018 040 065 039 024 021 036 041 013 030 022
013 093 106 017 019 027 030 042 012 021 043 013 014 020 027
019 040 029 023 016 024 015 026 011 010 026 017 012 013 014
022 042 030 040 019 015 016 011 012 009 008 012 009 017 019
022 026 018 030 020 012 017 010 008 011 007 015 008 016 034
019 018 048 029 012 054 012 008 008 009 008 012 007 016 005
022 015 057 043 126 135 122 006 005 008 007 019 010 011 008
018 008 009 019 023 093 109 128 063 052 031 010 012 009 006
017 010 010 007 067 054 106 116 067 056 011 028 005 009 006
015 010 012 014 062 076 057 055 019 024 020 006 005 013 004
016 010 008 011 039 025 020 016 011 007 008 007 006 010 003
015 009 010 010 012 011 014 009 008 007 007 005 005 008 002
014 007 008 011 007 012 010 009 007 008 007 005 005 007 003
020 011 015 019 013 017 017 013 019 013 012 013 011 009 005
020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
025 161 174 172 167 049 200 193 112 028 120 169 173 177 173

2d array of ints

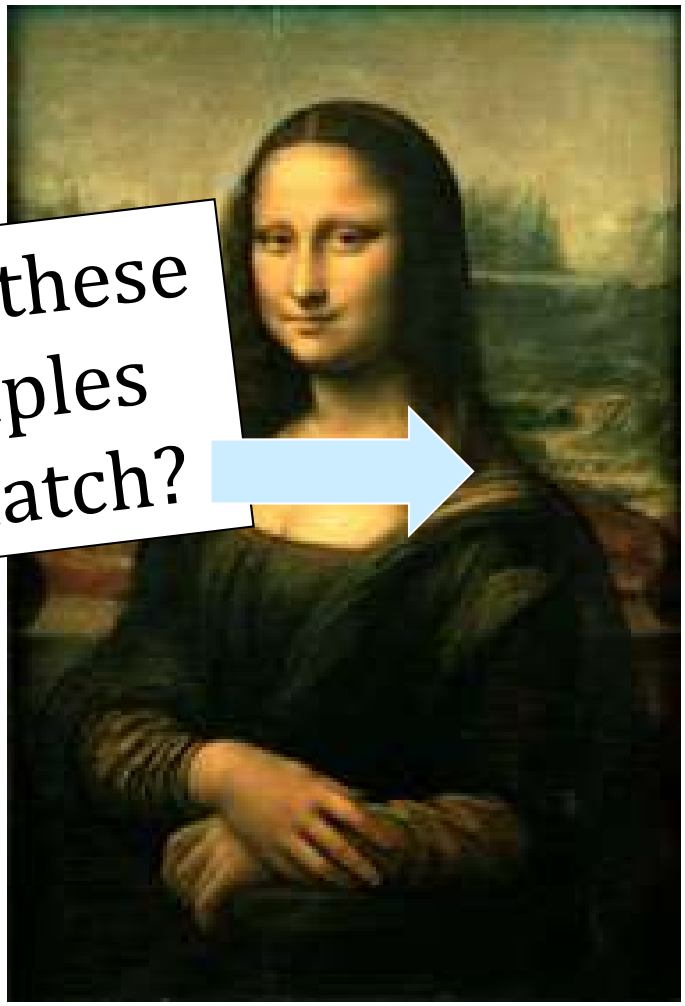
an image ... of what?

Input → ? Algorithm → Output

020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
047 109 107 118 107 115 110 120 120 124 120 128 124 132 131
047 125 130 130 122 121 117 142 131 133 134 141 149 144 135
051 139 143 139 147 134 149 069 127 144 139 144 150 161 149
054 136 161 148 147 158 055 052 034 030 158 156 165 163 156
043 144 165 159 154 171 224 191 047 030 171 165 175 164 163
025 161 174 172 167 049 200 193 112 028 120 169 173 177 173
011 091 101 105 177 039 078 060 041 026 073 102 167 208 121
011 091 094 066 094 033 199 184 139 024 060 094 125 152 134
009 068 072 072 065 031 151 171 075 028 035 072
013 068 074 059 057 037 161 12
012 042 063 055 072 033 020 067
011 037 064 094 091 026 025 080
011 060 077 082 037 023 024 147
013 049 076 059 032 028 174 197
013 059 111 072 020 078 200 211
007 053 057 092 023 105 189 230
011 061 072 018 27 054 069 068 0
014 041 047 0
013 093 106
019 040 029 02
022 042 030 040 019 015 016 011 01 009 008 012 009 017 019
022 026 018 030 020 012 017 010 008 011 007 015 008 016 034
019 018 048 029 012 054 012 008 008 009 008 012 007 016 005
022 015 057 043 126 135 122 006 005 008 007 019 010 011 008
018 008 009 019 023 093 109 128 063 052 031 010 012 009 006
017 010 010 007 067 054 106 116 067 056 011 028 005 009 006
015 010 012 014 062 076 057 055 019 024 020 006 005 013 004
016 010 008 011 039 025 020 016 011 007 008 007 006 010 003
015 009 010 010 012 011 014 009 008 007 007 005 005 008 002
014 007 008 011 007 012 010 009 007 008 007 005 005 007 003
020 011 015 019 013 017 017 013 019 013 012 013 011 009 005
020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
025 161 174 172 167 049 200 193 112 028 120 169 173 177 173

2d array of ints

btw, why is it clear these data/image examples definitely ***don't*** match?



an image ... of what?

Actual image 

Actual input: ***pixels***

207 200 199 194 203 126 106 091 113 153 192 196 190 186 175
242 194 213 254 255 114 082 109 097 089 208 206 202 194 185
254 159 187 245 248 128 197 191 166 102 248 251 233 223 246
255 159 191 245 249 123 113 047 124 149 255 253 239 143 250
255 184 191 249 249 126 022 040 115 039 250 255 255 177 252
253 197 190 233 251 054 143 209 196 014 254 254 253 228 251
252 228 176 218 251 070 176 219 200 024 250 255 255 254 195
248 244 163 227 252 091 071 185 079 021 252 251 255 254 138
253 254 169 241 253 141 053 180 005 019 253 253 255 253 201
253 250 170 242 253 138 199 193 216 146 255 253 253 253 233
254 228 164 209 235 144 188 144 161 192 230 250 253 255 252
252 240 140 215 245 119 098 086 139 127 252 234 253 253 251
253 246 169 207 235 120 157 140 188 108 246 249 235 225 255
253 230 167 207 217 113 106 069 168 098 244 246 239 207 254
253 219 170 225 253 122 144 169 124 109 243 235 233 252 252
255 221 179 239 227 123 123 069 125 122 240 249 243 232 253
221 217 180 213 243 126 143 081 181 133 252 249 244 221 210
236 216 178 208 230 225 160 118 187 198 249 249 230 220 221
229 224 183 217 216 165 209 133 193 209 222 238 236 220 214
230 223 185 240 225 212 027 187 202 239 233 234 237 225 232
221 215 189 207 220 221 003 063 209 006 204 203 232 229 216
223 217 198 162 194 215 192 106 077 255 213 219 194 215 219
224 216 162 189 200 254 217 198 209 216 206 226 186 228 219
215 222 168 202 214 201 117 084 085 111 234 190 248 218 226
219 216 198 165 213 227 014 221 197 183 178 186 216 214 222
222 224 197 146 201 204 108 220 201 210 196 223 200 233 218
226 232 177 184 175 230 214 199 146 255 134 225 205 216 181
253 254 194 192 196 168 032 193 194 196 040 198 190 207 185
045 030 167 163 210 041 206 144 129 170 086 190 161 193 191
200 205 135 143 100 174 027 175 189 113 121 150 190 209 184
202 205 138 213 088 037 164 194 194 182 076 077 107 211 181
196 208 155 063 055 068 180 200 193 160 220 082 070 210 181
161 132 058 146 048 076 172 165 218 189 186 063 004 187 185
157 080 191 119 044 025 089 115 063 192 223 146 116 186 187

020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
047 109 107 118 107 115 110 120 120 124 120 128 124 132 131
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007 053 057 092 023 105 189 230 210 084 034 021 017 033 091
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019 040 029 023 016 024 015 026 011 010 026 017 012 013 014
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022 026 018 030 020 012 017 010 008 011 007 015 008 016 034
019 018 048 029 012 054 012 008 008 009 008 012 007 016 005
022 015 057 043 126 135 122 006 005 008 007 019 010 011 008
018 008 009 019 023 093 109 128 063 052 031 010 012 009 006
017 010 010 007 067 054 106 116 067 056 011 028 005 009 006
015 010 012 014 062 076 057 055 019 024 020 006 005 013 004
016 010 008 011 039 025 020 016 011 007 008 007 006 010 003
015 009 010 010 012 011 014 009 008 007 007 005 005 008 002
014 007 008 011 007 012 010 009 007 008 007 005 005 007 003
020 011 015 019 013 017 017 013 019 013 012 013 011 009 005
020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
025 161 174 172 167 049 200 193 112 028 120 169 173 177 173

207 200 191 194 203 131 100 078 093 145 192 196 190 186 175
242 194 221 254 255 126 063 061 052 060 208 206 202 194 185
254 176 211 255 250 126 116 086 070 064 253 252 233 239 253
251 180 203 255 251 123 075 030 070 072 255 253 239 156 255
255 206 194 255 246 141 019 021 035 026 250 255 255 184 255
253 219 190 239 248 119 061 095 065 011 254 254 253 231 255
252 247 181 218 251 142 066 142 080 026 250 255 255 255 204
248 251 167 227 252 146 047 073 047 021 252 251 255 255 145
253 255 170 255 253 147 040 094 000 020 253 253 255 255 203
253 250 170 255 253 144 092 077 106 057 255 253 253 255 238
254 228 173 214 235 145 083 073 058 089 230 250 253 252 253
252 245 140 215 245 125 038 027 044 042 252 234 253 253 252
255 251 169 214 235 110 075 065 060 052 246 249 235 225 255
255 235 167 216 217 105 048 038 046 046 244 246 239 207 254
254 219 170 247 253 104 121 057 042 047 243 235 233 252 254
255 221 179 255 227 099 058 029 034 052 240 249 243 232 253
221 217 180 213 243 081 052 029 055 023 250 249 244 221 210
236 216 178 208 230 149 043 037 056 075 241 249 230 220 221
229 224 183 213 121 036 076 034 069 073 116 248 236 220 214
230 223 185 178 098 070 010 070 097 098 108 101 236 223 232
221 215 190 084 122 070 011 018 075 013 076 079 146 227 216
223 217 120 033 059 071 042 044 013 155 060 070 076 213 219
224 216 030 082 075 139 076 083 099 114 076 133 057 228 219
215 222 033 092 067 063 031 023 070 025 125 055 136 224 226
219 216 076 044 069 119 011 102 078 055 043 054 111 226 222
222 224 063 046 065 080 101 090 054 104 109 123 052 216 218
226 232 086 080 042 123 083 054 031 148 045 072 067 061 164
253 255 072 058 079 056 006 046 056 061 026 085 082 048 127
046 033 080 045 105 027 071 067 054 036 035 059 060 048 120
174 173 047 042 019 055 011 044 095 033 031 052 054 061 118
173 175 039 127 038 024 053 054 050 051 036 038 022 063 126
170 160 058 020 027 027 045 074 057 035 124 036 016 072 124
107 054 027 044 020 035 062 039 115 048 051 046 005 051 117
098 006 045 033 030 027 036 054 025 072 112 044 029 060 115

Actual output: ***contents***

a woman, smiling?

Actual image 

Actual input: ***pixels***

207 200 199 194 203 126 106 091 113 153 192 196 190 186 175
242 194 213 254 255 114 082 109 097 089 208 206 202 194 185
254 159 187 245 248 128 197 191 166 102 248 251 233 223 246
255 159 191 245 249 123 113 047 124 149 255 253 239 143 250
255 184 191 249 249 126 022 040 115 039 250 255 255 177 252
253 197 190 233 251 054 143 209 196 014 254 254 253 228 251
252 228 176 218 251 070 176 219 200 024 250 255 255 254 195
248 244 163 227 252 091 071 185 079 021 252 251 255 254 138
253 254 169 241 253 141 053 180 005 019 253 253 255 253 201
253 250 170 242 253 138 199 193 216 146 255 253 253 253 233
254 228 164 209 235 144 188 144 161 192 230 250 253
252 240 140 215 245 119 098 086
253 246 169 207
253 230 167
253 219 170
255 221 179
221 217 180
236 216 178
229 224 183 217 216 165 209 133 193 209 222 238 236 220 214
230 223 185 240 225 212 027 187 202 239 233 234 237 225 232
221 215 189 207 220 221 003 063 209 006 204 203 232
223 217 198 162 194 215 192 106
224 216 162 189 200 254
215 222 168 202 214 201
219 216 198 165 213 227
222 224 197 146 201 204
226 232 177 184 175 230
253 254 194 192 196 168 032
045 030 167 163 210 041 206 144 129 170 086 190 161 193 191
200 205 135 143 100 174 027 175 189 113 121 150 190 209 184
202 205 138 213 088 037 164 194 194 182 076 077 107 211 181
196 208 155 063 055 068 180 200 193 160 220 082 070 210 181
161 132 058 146 048 076 172 165 218 189 186 063 004 187 185
157 080 191 119 044 025 089 115 063 192 223 146 116 186 187

020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
047 109 107 118 107 115 110 120 120 124 120 128 124 132 131
047 125 130 130 122 121 117 142 131 133 134 141 149 144 135
051 139 143 139 147 134 149 069 127 144 139 144 150 161 149
054 136 161 148 147 158 055 052 034 030 158 156 165 163 156
043 144 165 159 154 171 224 191 047 030 171 165 175 164 163
025 161 174 172 167 049 200 193 112 028 120 169
011 091 101 105 177 039 078
011 091 094
070 073 060
066 026 023 071 070 080 060
037 023 024 147 140 038 023 037 043 076 037
013 049 076 059 032 028 174 197 182 060 021 021 121 101 062
013 059 111 072 020 078 200 211 182 061 069 059 043 086 106
007 053 057 092 023 105 189 230 210 084 034
011 061 072 018 027 054 069 068
014 041 047 025
015 008 016 034
012 008 008 009 008 012 007 016 005
043 126 135 122 006 005 008 007 019 010 011 008
018 008 009 019 023 093 109 128 063 052 031 010 012 009 006
017 010 010 007 067 054 106 116 067 056 011 028 005 009 006
015 010 012 014 062 076 057 055 019 024 020 006 005 013 004
016 010 008 011 039 025 020 016 011 007 008 007 006 010 003
015 009 010 010 012 011 014 009 008 007 007 005 005 008 002
014 007 008 011 007 012 010 009 007 008 007 005 005 007 003
020 011 015 019 013 017 017 013 019 013 012 013 011 009 005
020 067 073 058 055 076 069 050 074 064 065 066 066 059 023
025 161 174 172 167 049 200 193 112 028 120 169 173 177 173

207 200 191 194 203 131 100 078 093 145 192 196 190 186 175
242 194 221 254 255 126 063 061 052 060 208 206 202 194 185
254 176 211 255 250 126 116 086 070 064
251 180 203 255 251 123
255 206 194
094 000 020 253 253 255 255 203
255 253 144 092 077 106 057 255 253 253 255 238
254 228 173 214 235 145 083 073 058 089 230 250 253 252 253
252 245 140 215 245 125 038 027 044 042 252 234 253 253 252
255 251 169 214 235 110 075 065 060 052 246 249 235 225 255
255 235 167 216 217 105
254 219 170
116 248 236 220 214
010 070 097 098 108 101 236 223 232
190 084 122 070 011 018 075 013 076 079 146 227 216
223 217 120 033 059 071 042 044 013 155 060 070 076 213 219
224 216 030 082 075 139 076 083 099 114 076 133 057 228 219
215 222 033 092 067 063 031 023 070 025 125 055 136 224 226
219 216 076 044 069 119 011 102 078 055 043 054 111 226 222
222 224 063 046 065 080 101 090 054 104 109 123 052 216 218
226 232 086 080 042 123 083 054 031 148 045 072 067 061 164
253 255 072 058 079 056 006 046 056 061 026 085 082 048 127
046 033 080 045 105 027 071 067 054 036 035 059 060 048 120
174 173 047 042 019 055 011 044 095 033 031 052 054 061 118
173 175 039 127 038 024 053 054 050 051 036 038 022 063 126
170 160 058 020 027 027 045 074 057 035 124 036 016 072 124
107 054 027 044 020 035 062 039 115 048 051 046 005 051 117
098 006 045 033 030 027 036 054 025 072 112 044 029 060 115

Happily, this problem is **being** solved...

but why is it so challenging?

Actual output: ***contents***

a woman, smiling?

MIT AI Memo #100

thanks to Rodney Brooks!

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

Artificial Intelligence Group — July 7, 1966
Vision Memo. No. 100.

THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

The basic structure is fixed for the first phase of work extending to some point in July. Everyone is invited to contribute to the discussion of the second phase. Sussman is coordinator of "Vision Project" sophomore meetings and should be consulted by anyone who wishes to participate.

Goals - General

The primary goal of the project is to construct a system of programs which will divide a vidisector picture into regions such as

likely objects

likely background areas

chaos.

We shall call this part of its operation FIGURE-GROUND analysis.

It will be impossible to do this without considerable analysis of shape and surface properties, so FIGURE-GROUND analysis is really inseparable in practice from the second goal which is REGION DESCRIPTION.

Subgoal for July

Analysis of scenes consisting of non-overlapping objects from the following set:

balls

bricks with faces of the same or different colors or textures

cylinders.

Each face will be of uniform and distinct color and/or texture. Background will be homogeneous.

Extensions for August

The first priority will be to handle objects of the same sort but with complex surfaces and backgrounds, e.g. cigarette pack with writing and bands of different color, or a cylindrical battery.

Then extend class of objects to objects like tools, cups, etc.

What's red?

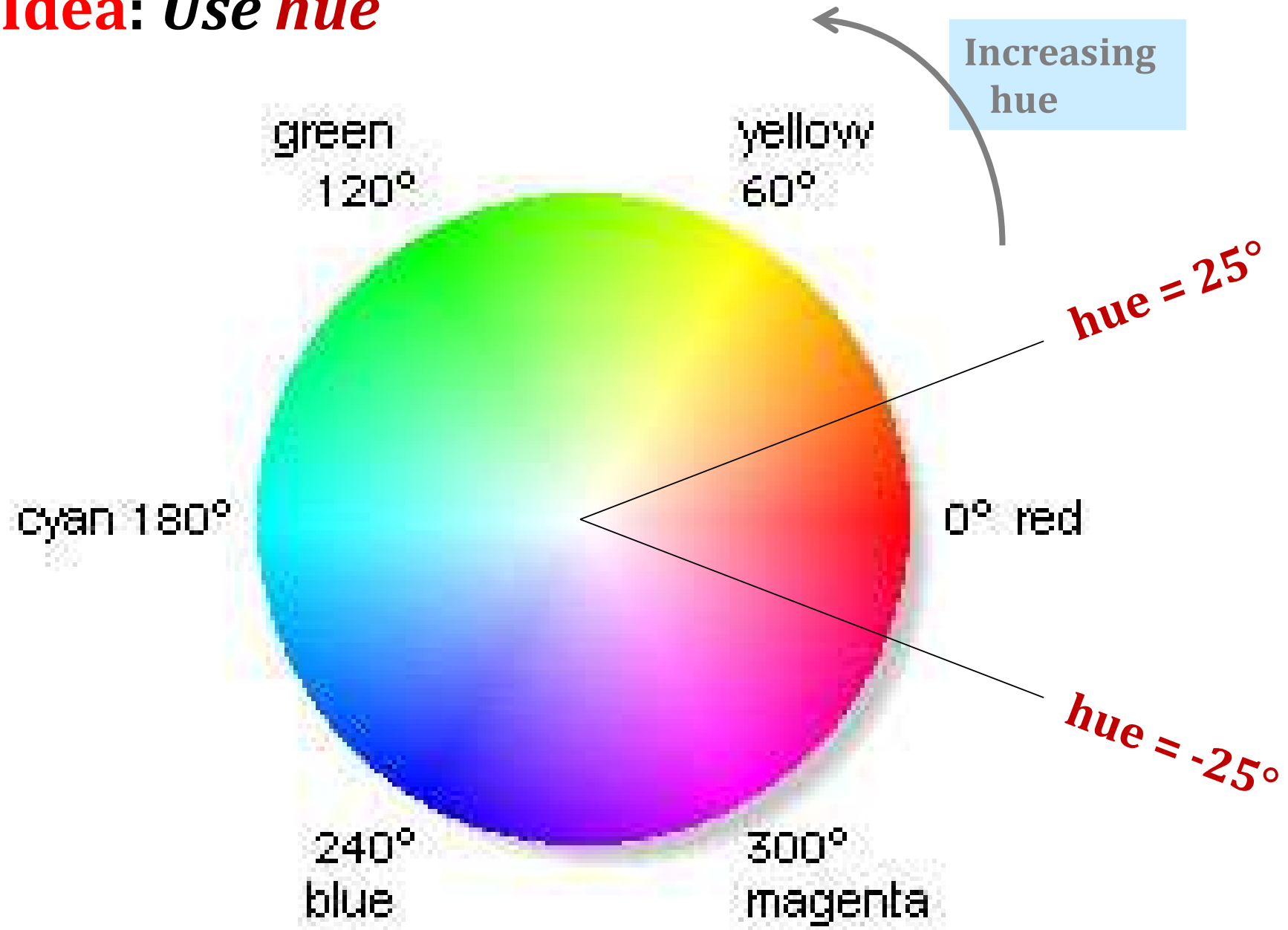
Goal: a coke-can collecting robot…

What's red?

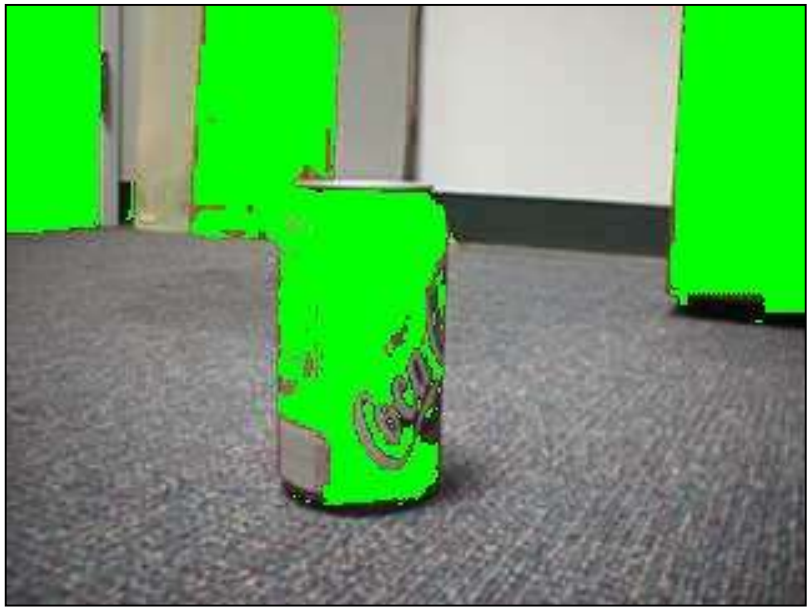
red > 200

not good enough…

Idea: *Use hue*


Increasing hue
green 120°
yellow 60°
hue = 25°
cyan 180°
0° red
hue = -25°
240° blue
300° magenta

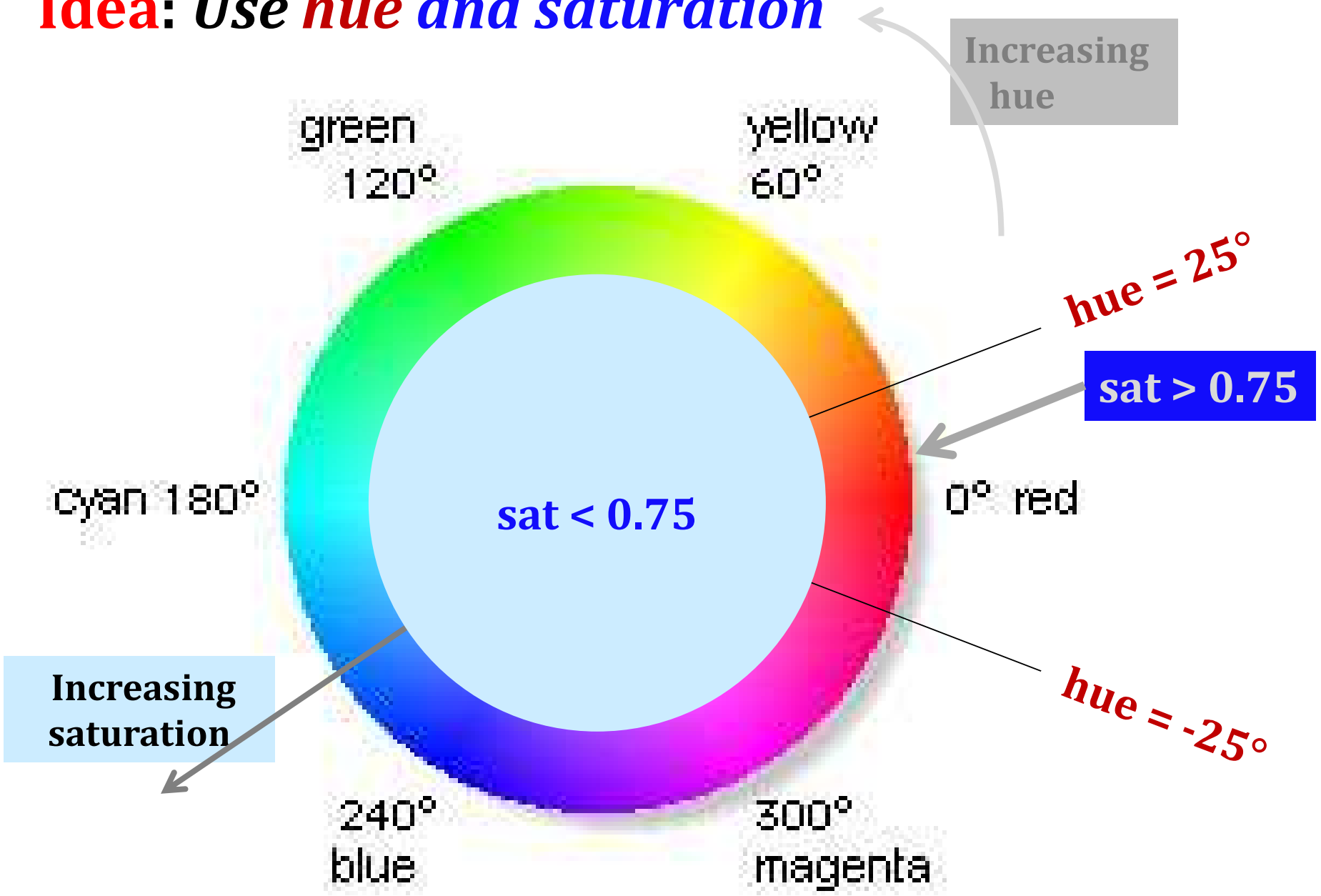
What's red?



-25 < hue < 25

hue's too much!

Idea: *Use hue and saturation*



What's red?

-25 < hue < 25

saturation > 0.75

The door is still matched, too… ***why?***

What's red?

Aargh!

Remarkably, this problem is, in a sense, ***our own*** vision systems' fault...!

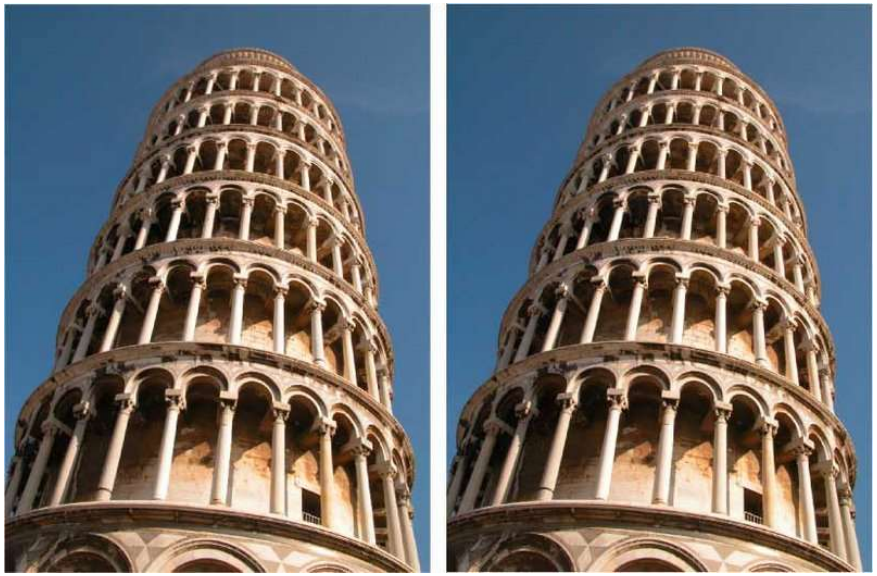
< hue < 25

uration > 0.75

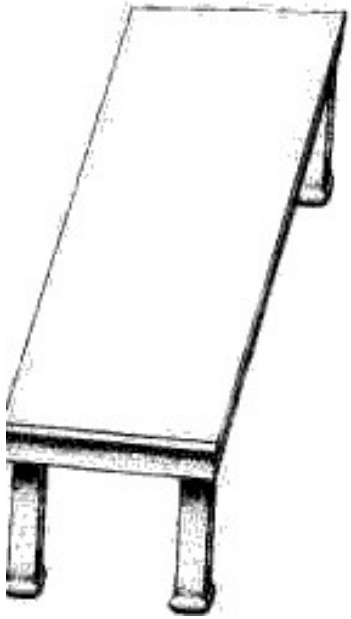
door is still matched, too... ***why?***

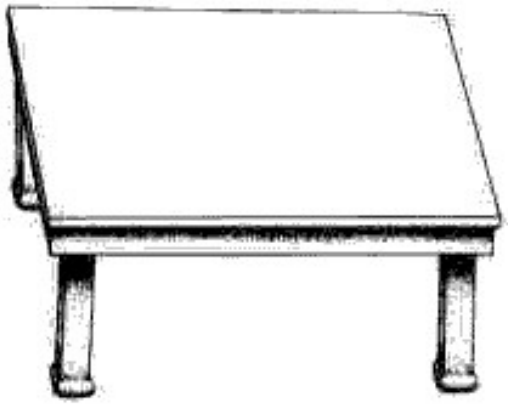
Try it! *Illusions? What **computations** is your brain doing to cause them?* **Why?**

two tones



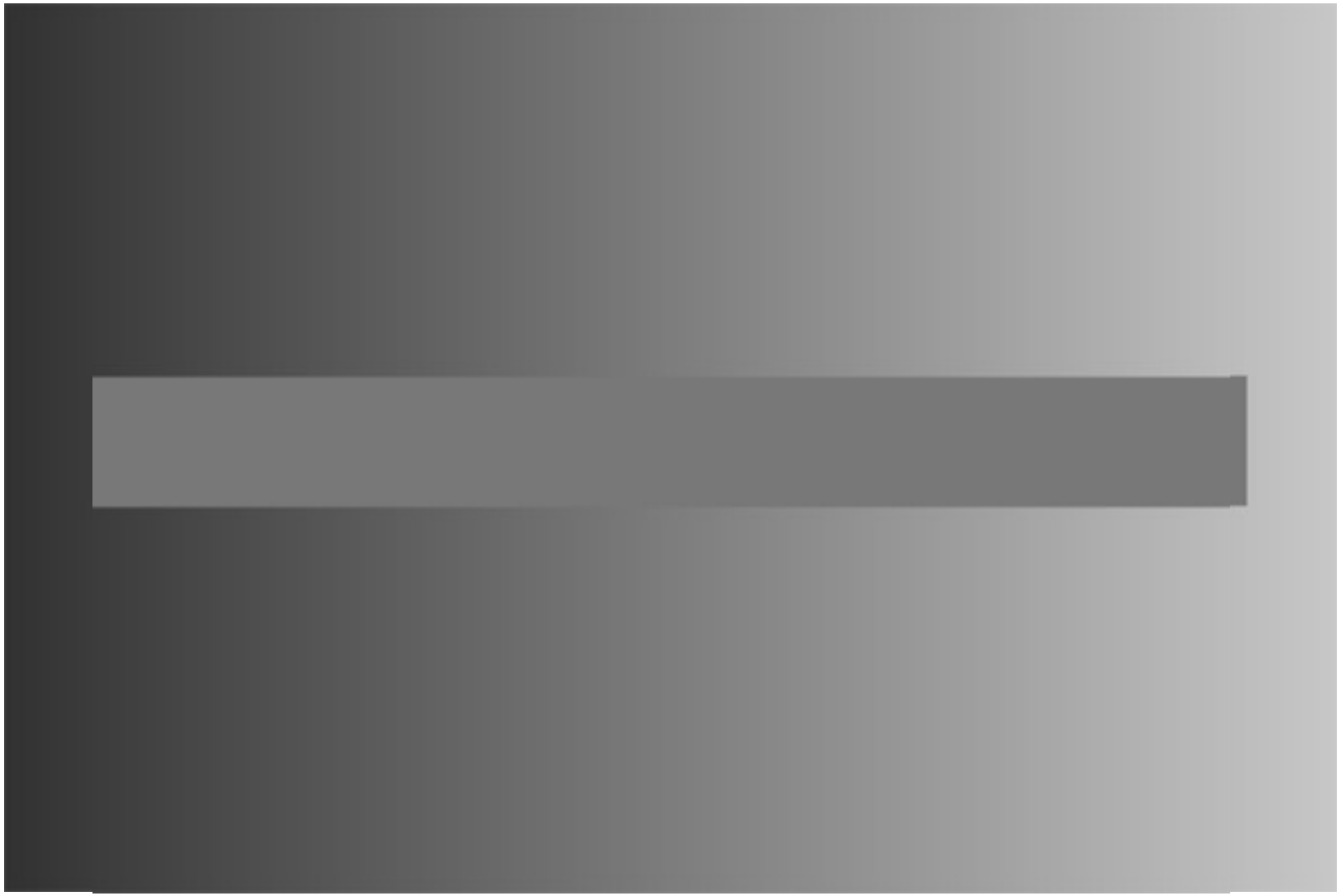
two towers



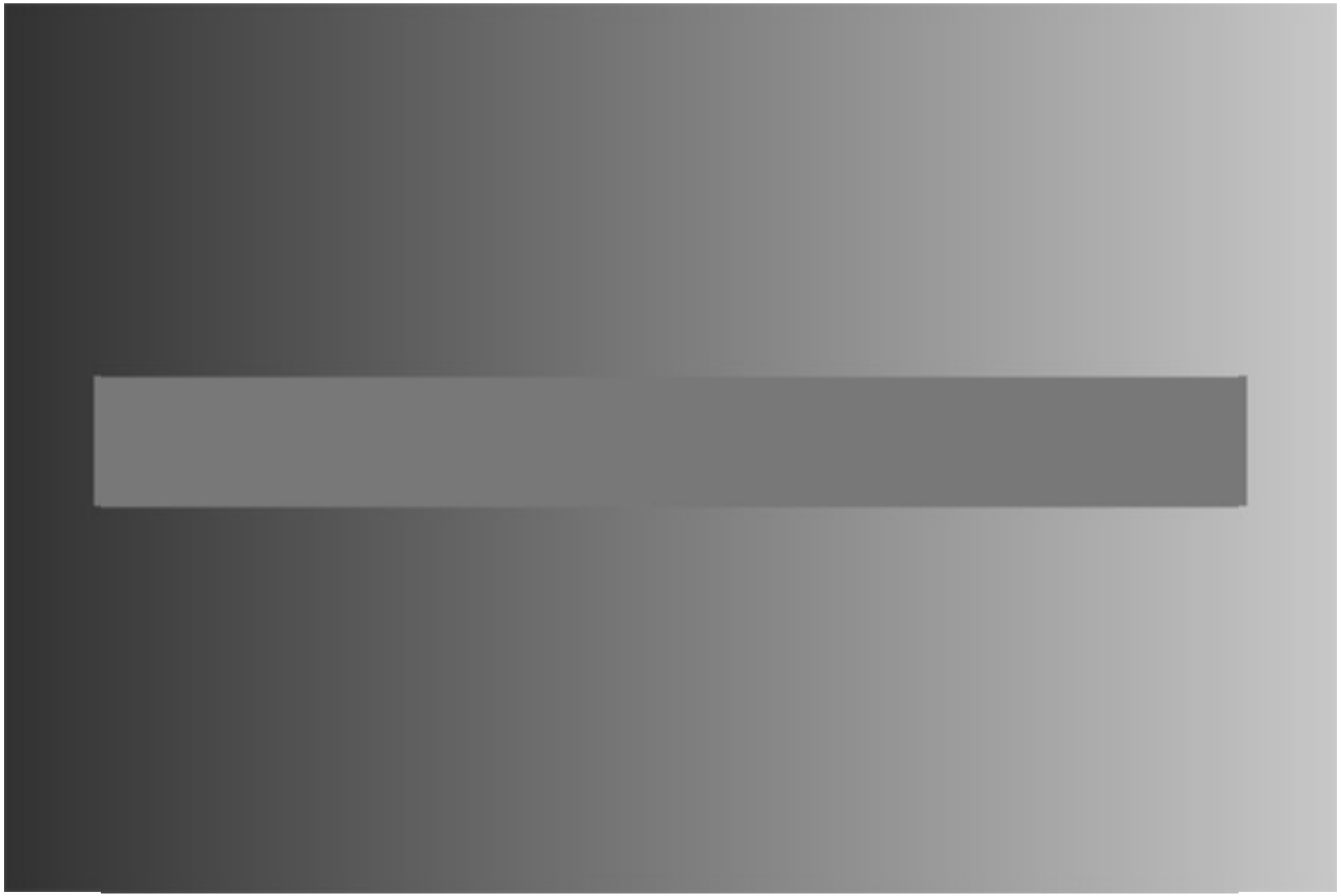


two tables

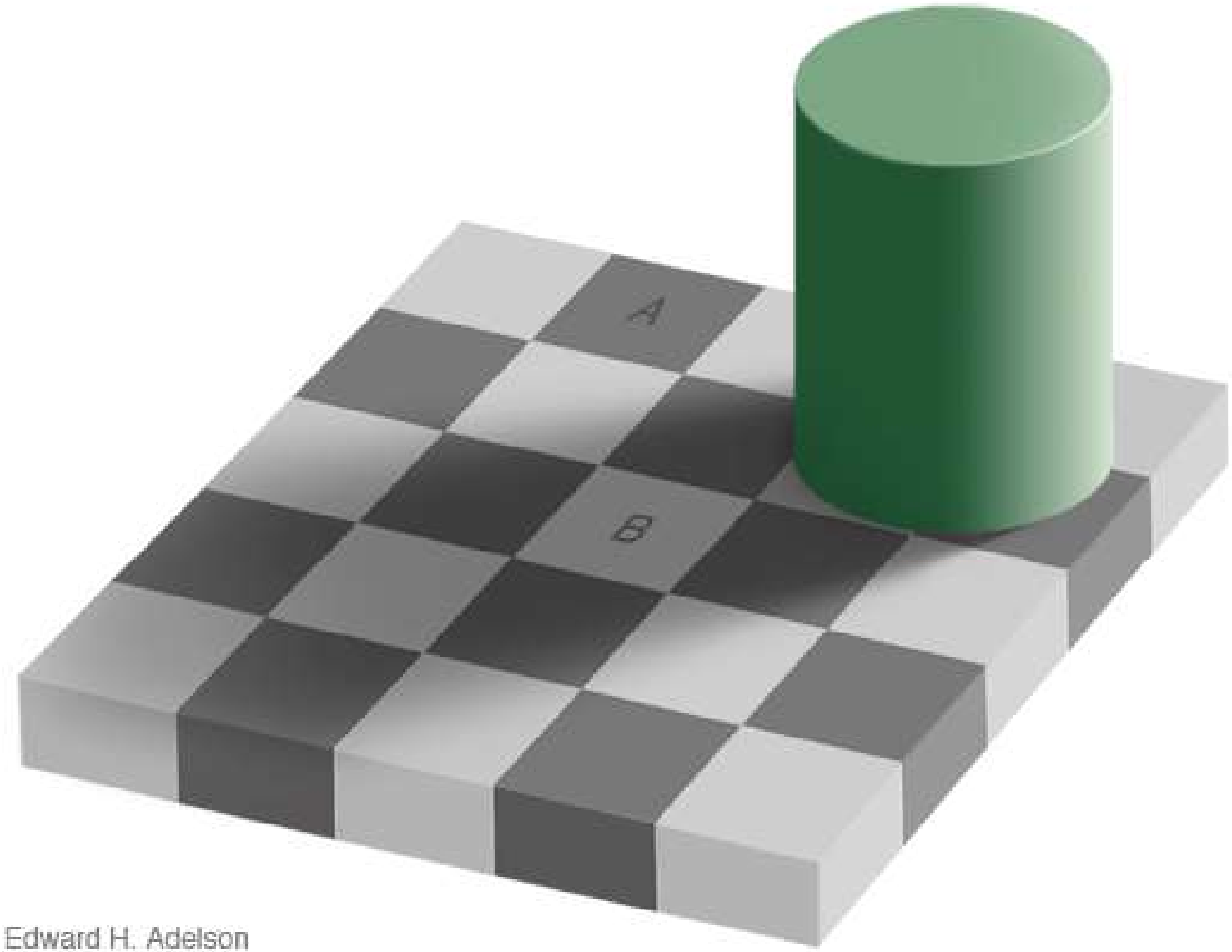
two segments



2 layers

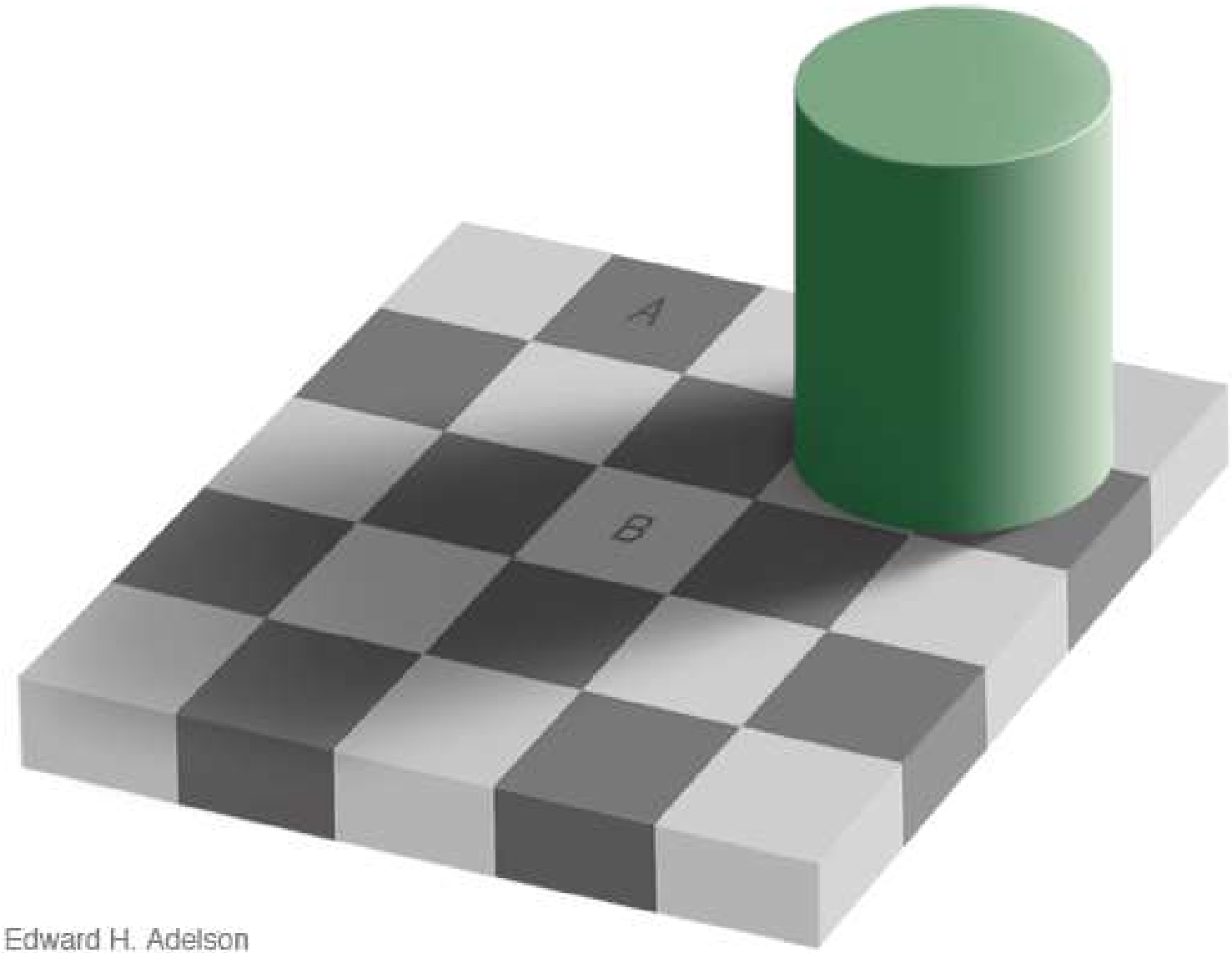


2 layers



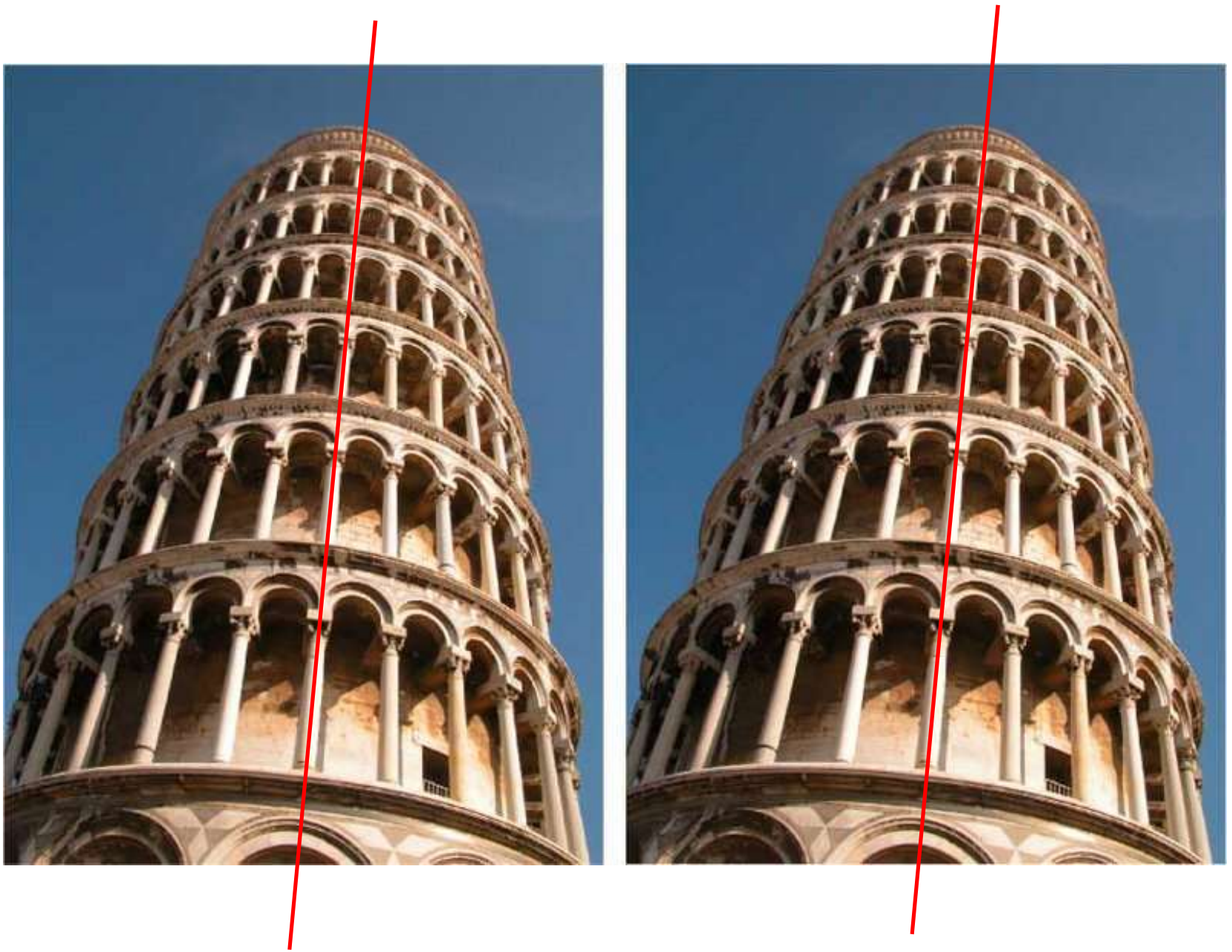
Edward H. Adelson

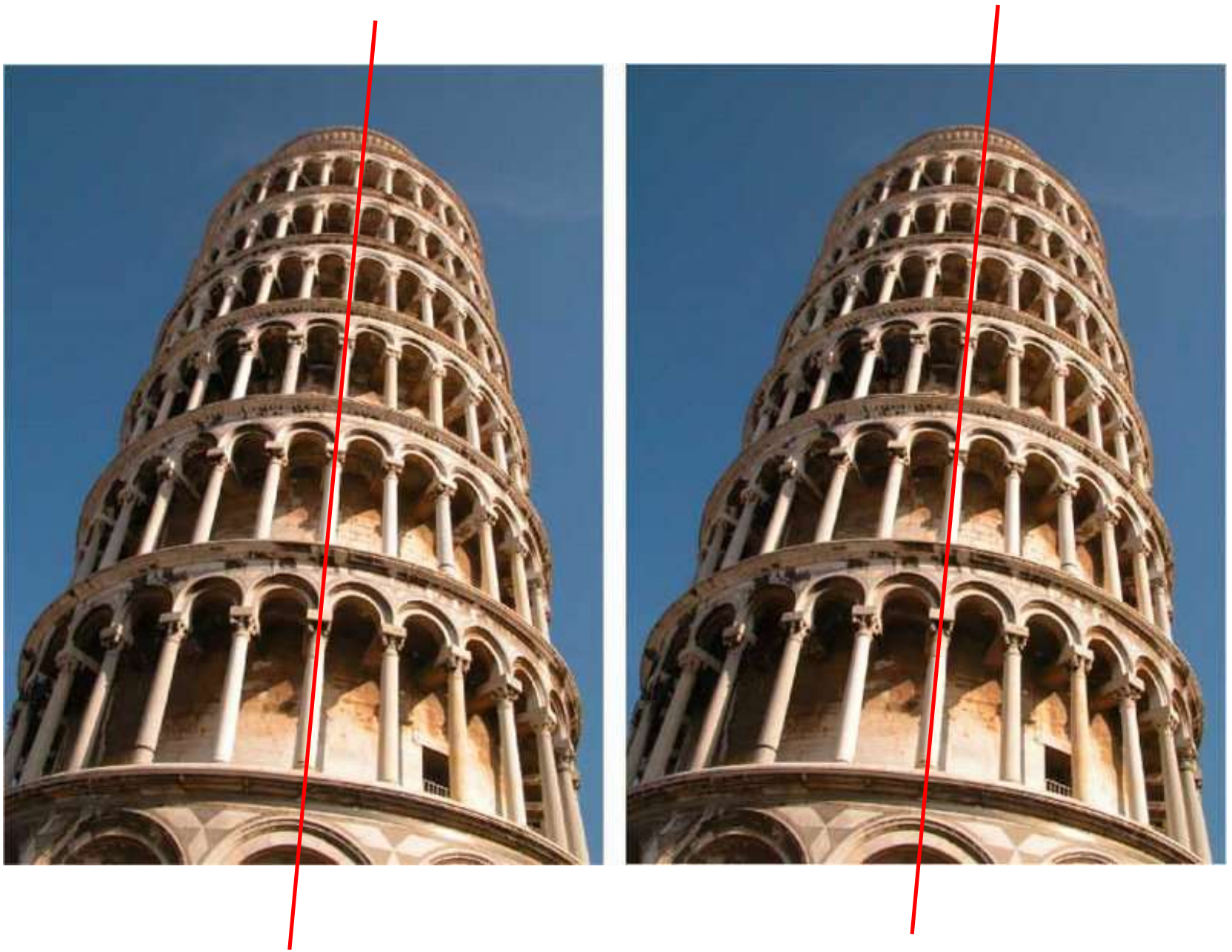
2 layers



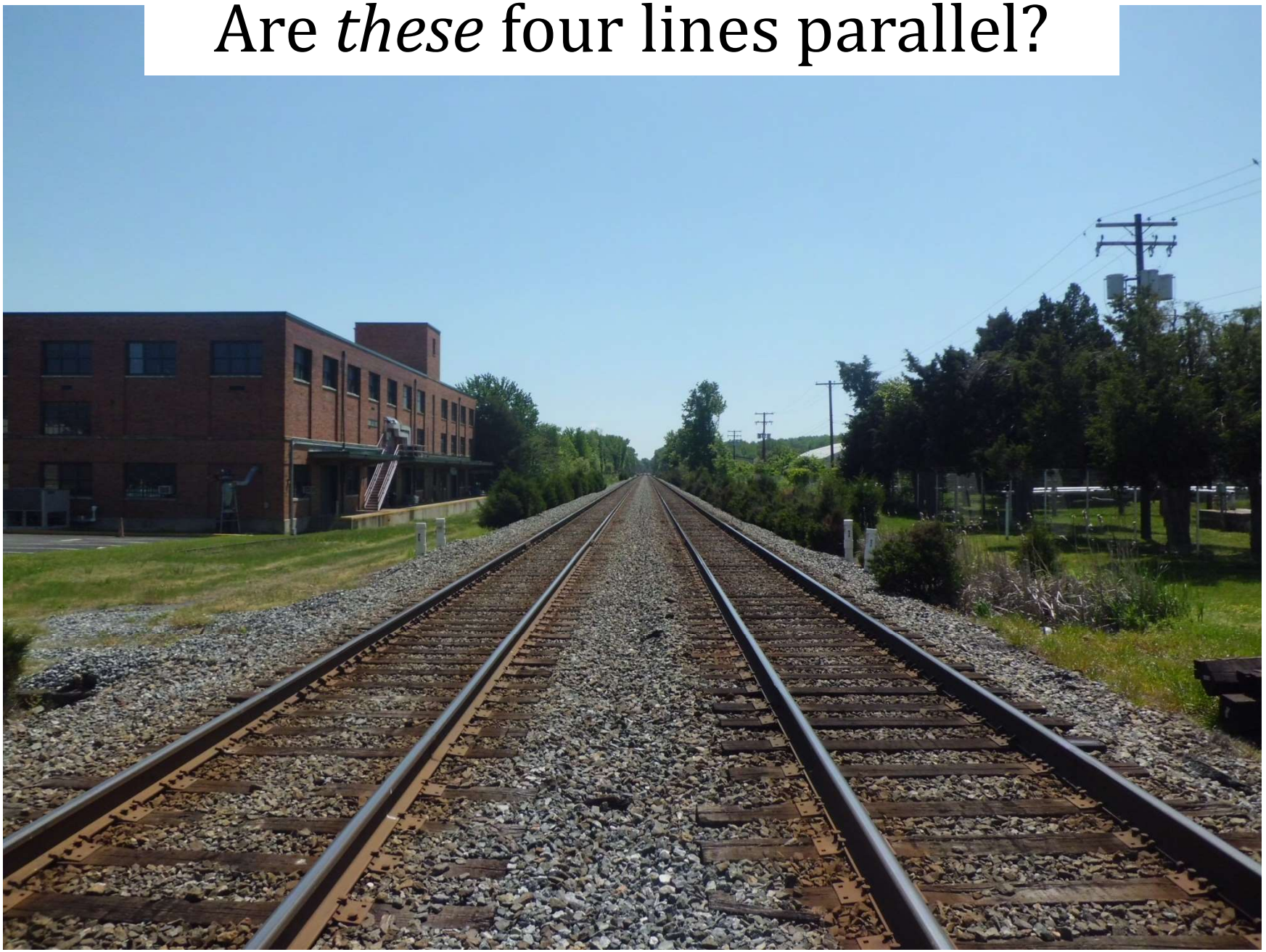
Edward H. Adelson

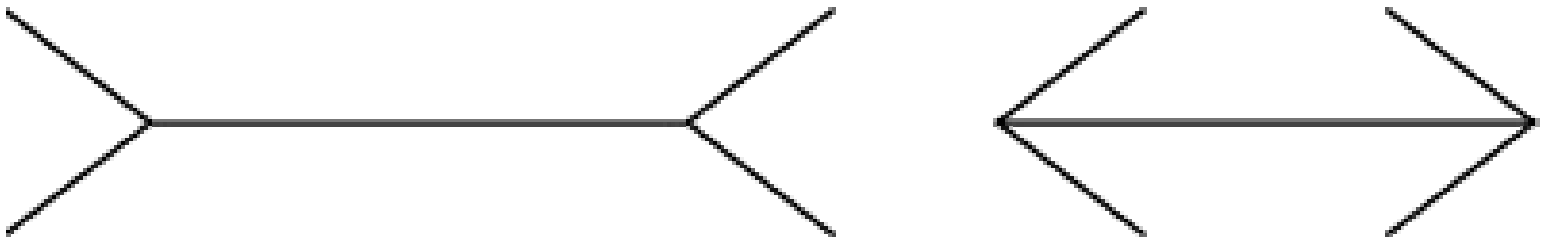
2 layers

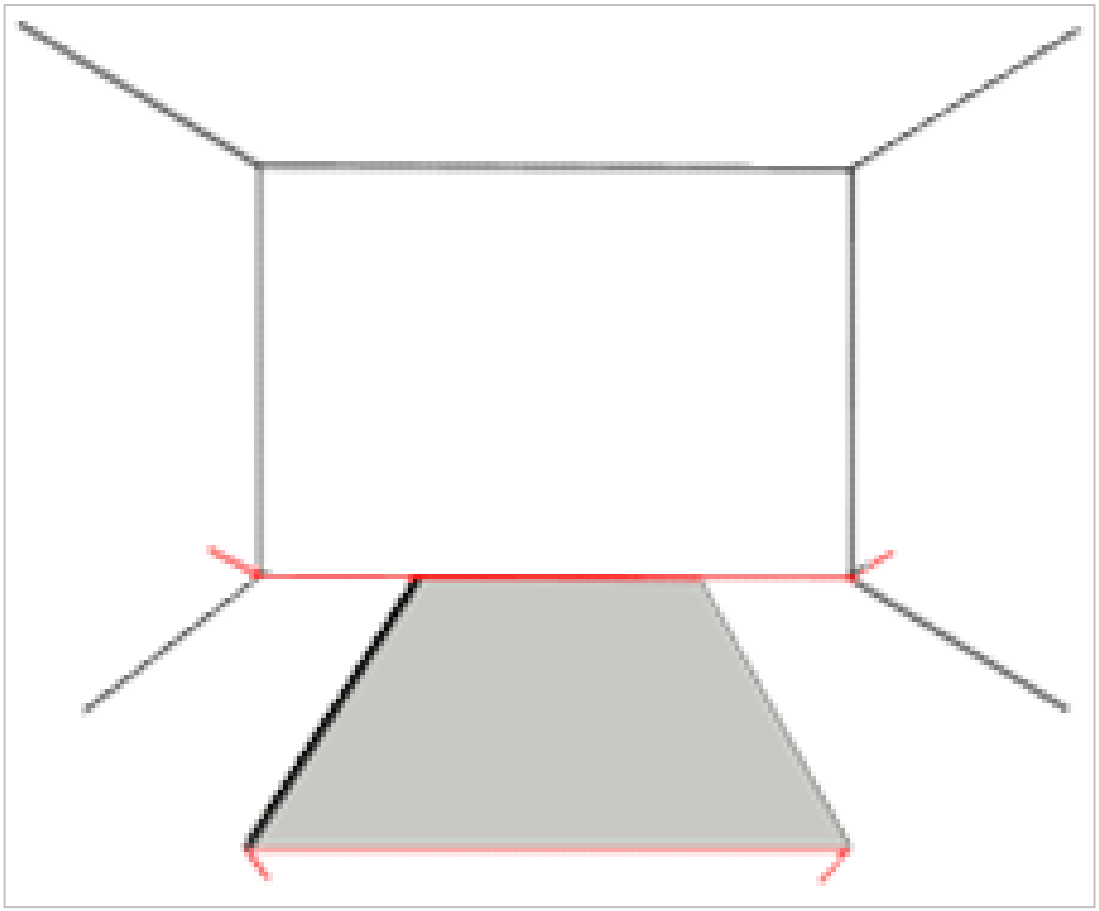


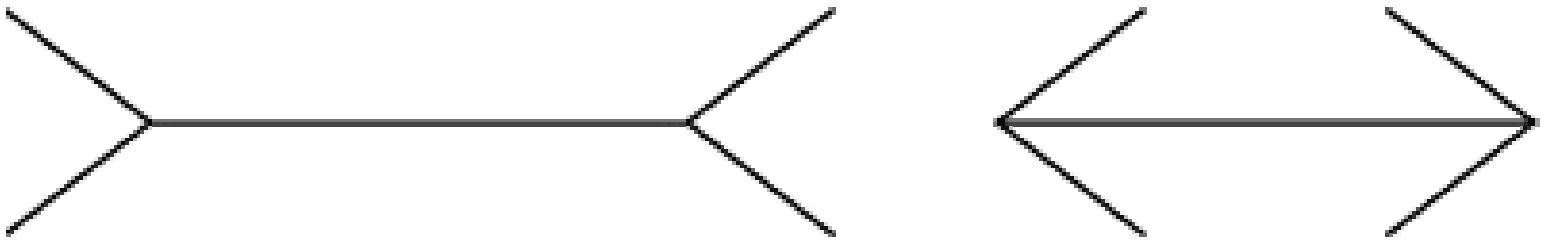


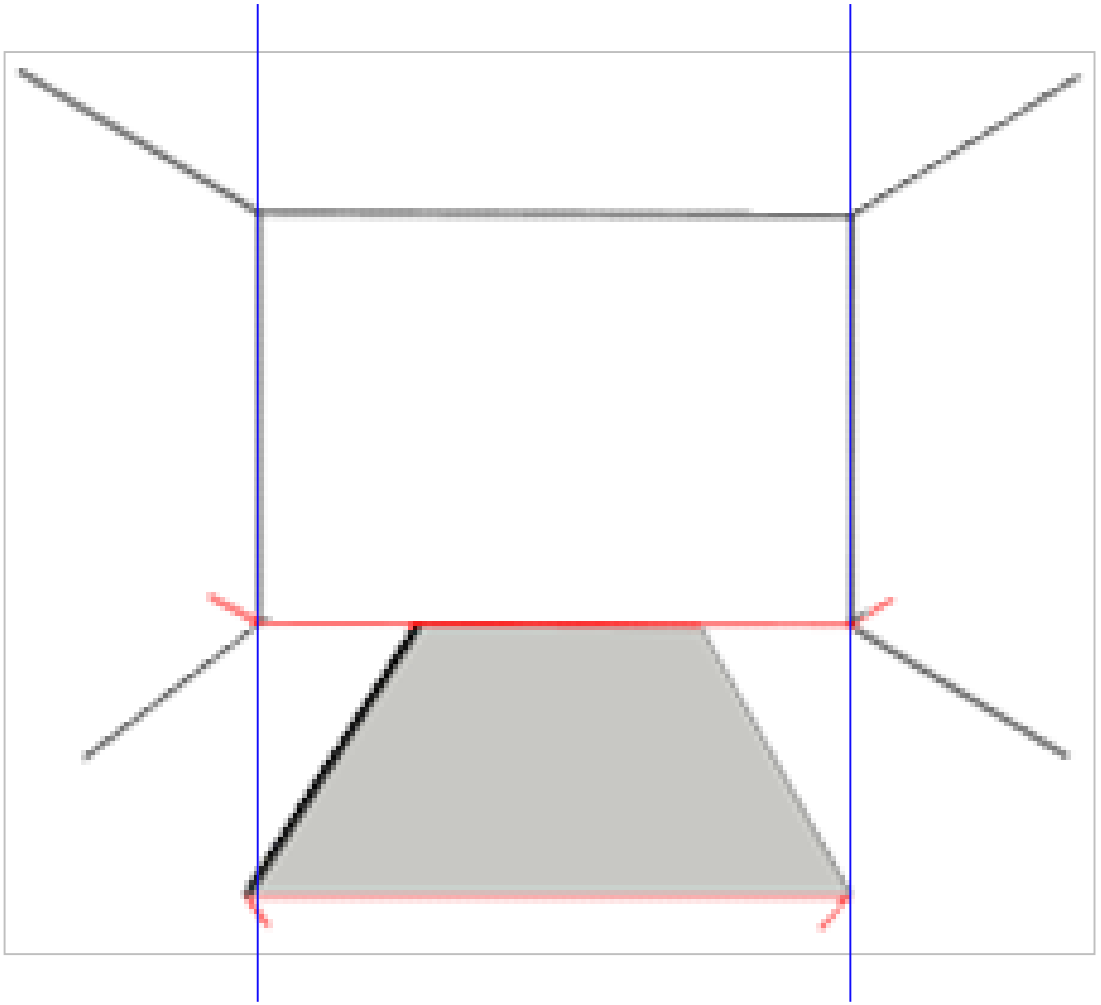
Are *these* four lines parallel?

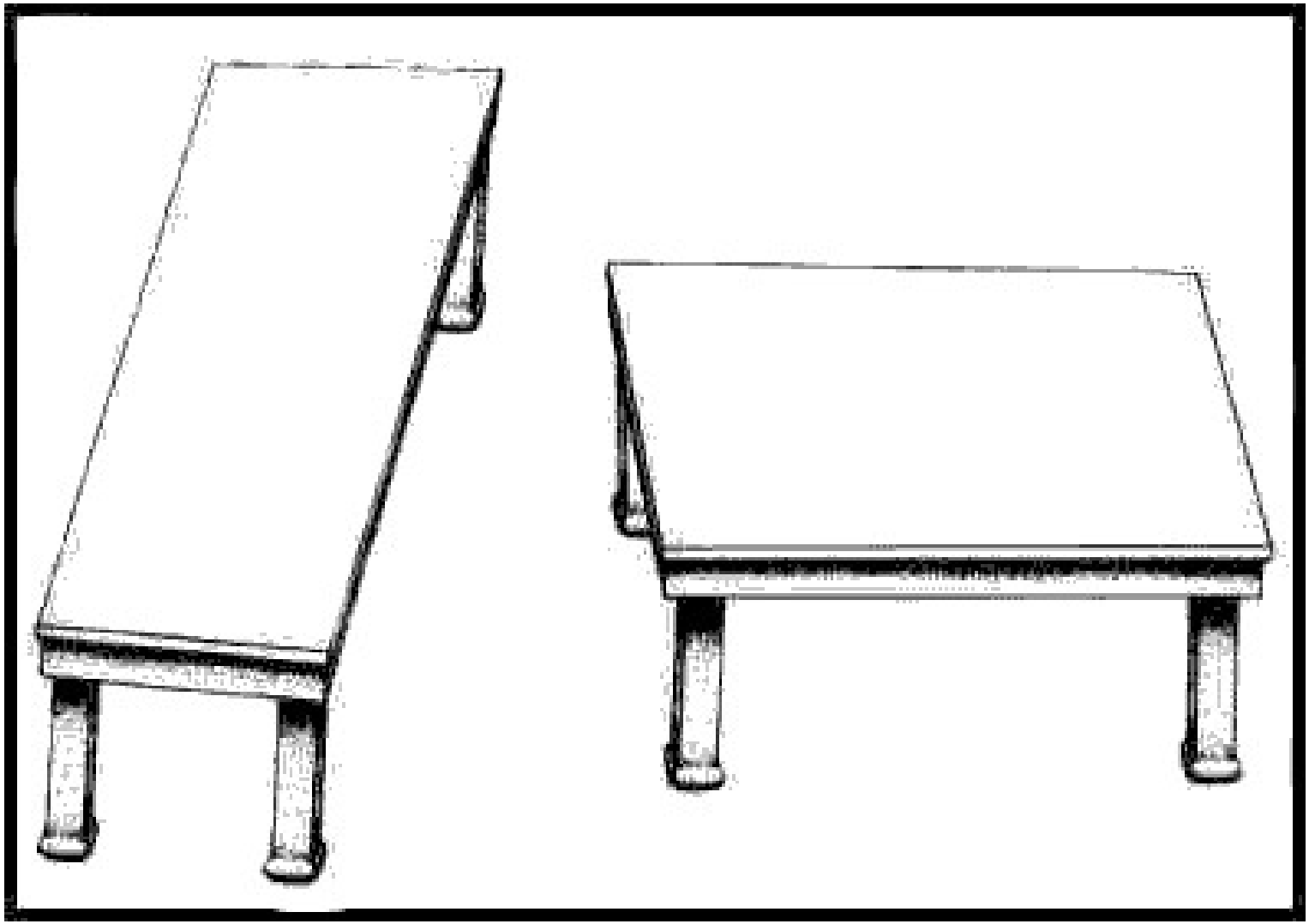


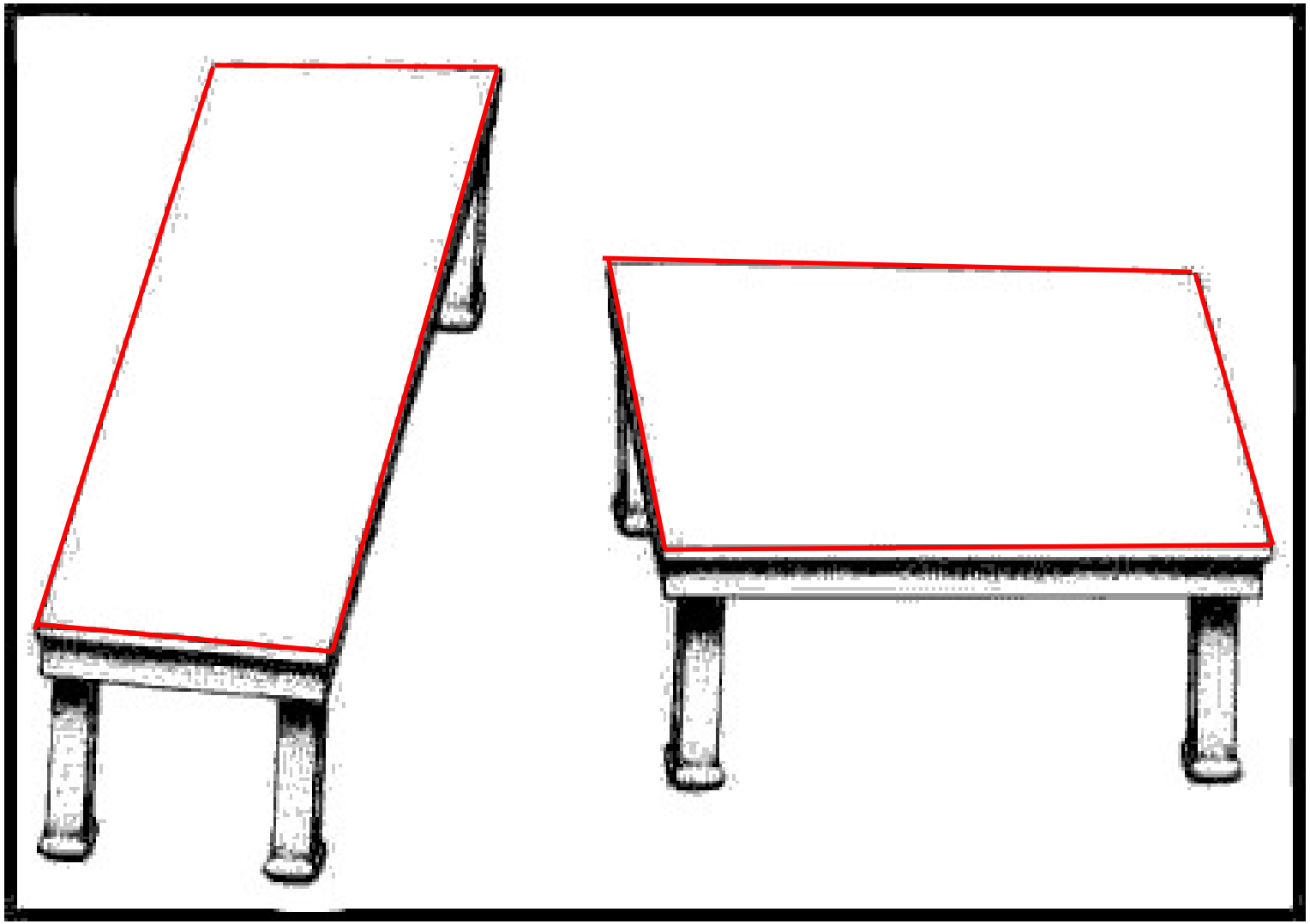


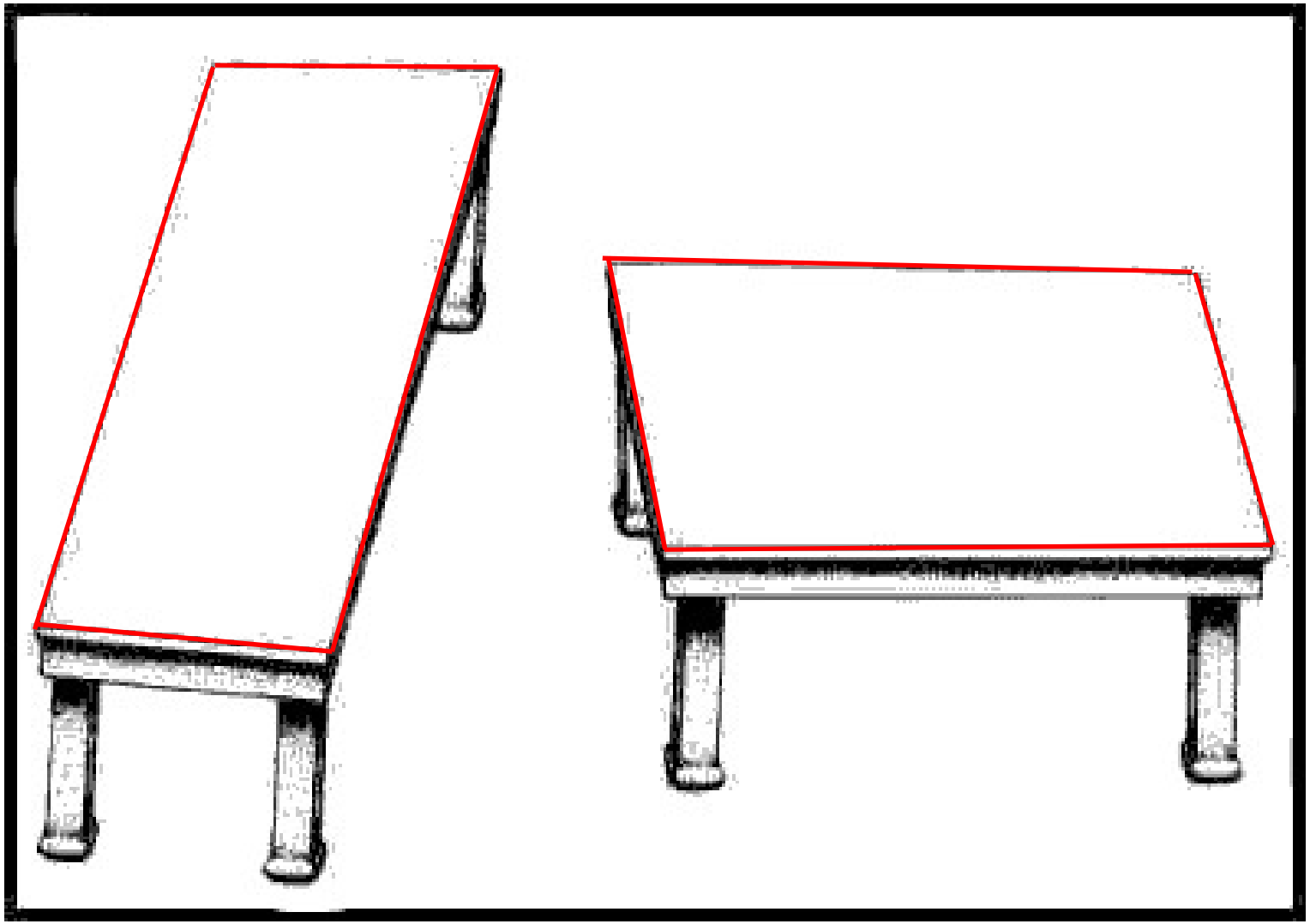




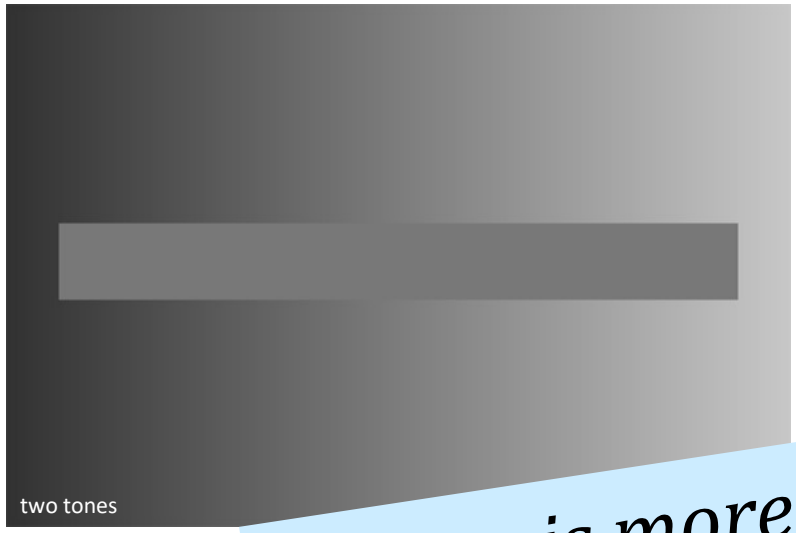








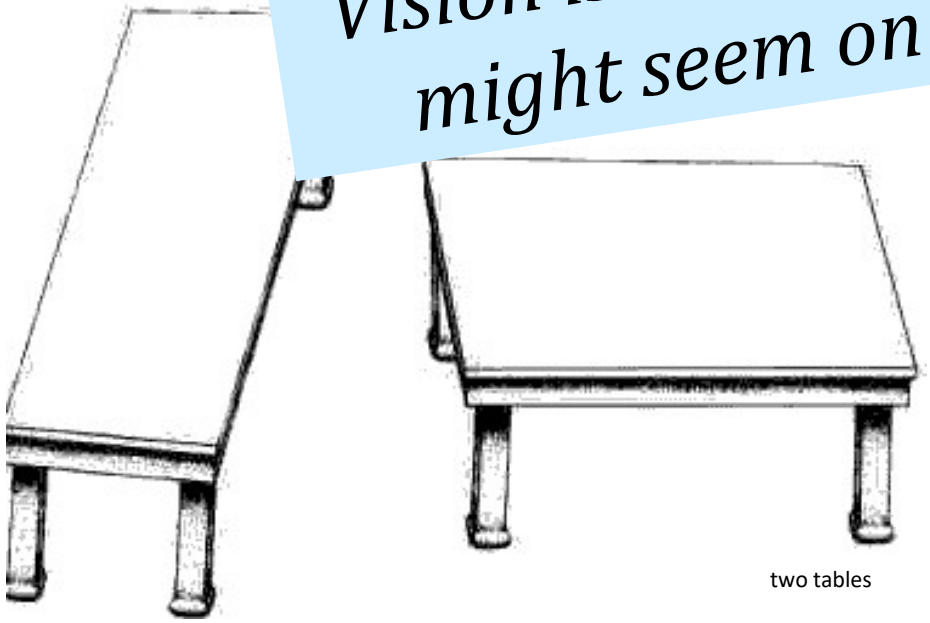
Try it! *Illusions? What **computations** is your brain doing to cause them?* **Why?**



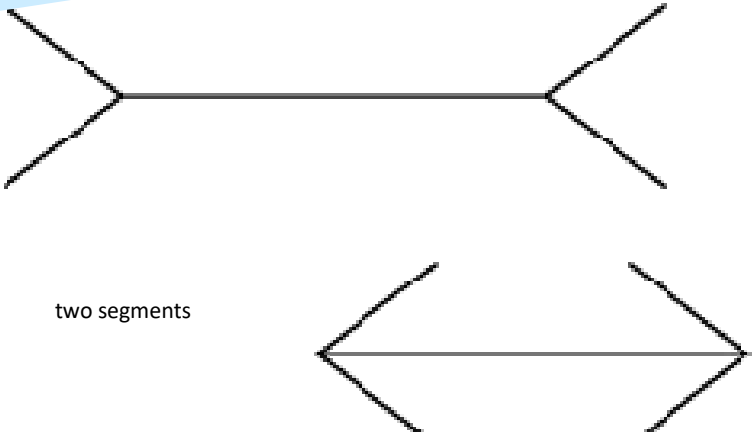
two tones

two towers

*Vision is more challenging than it might seem on first "**glance**"!*

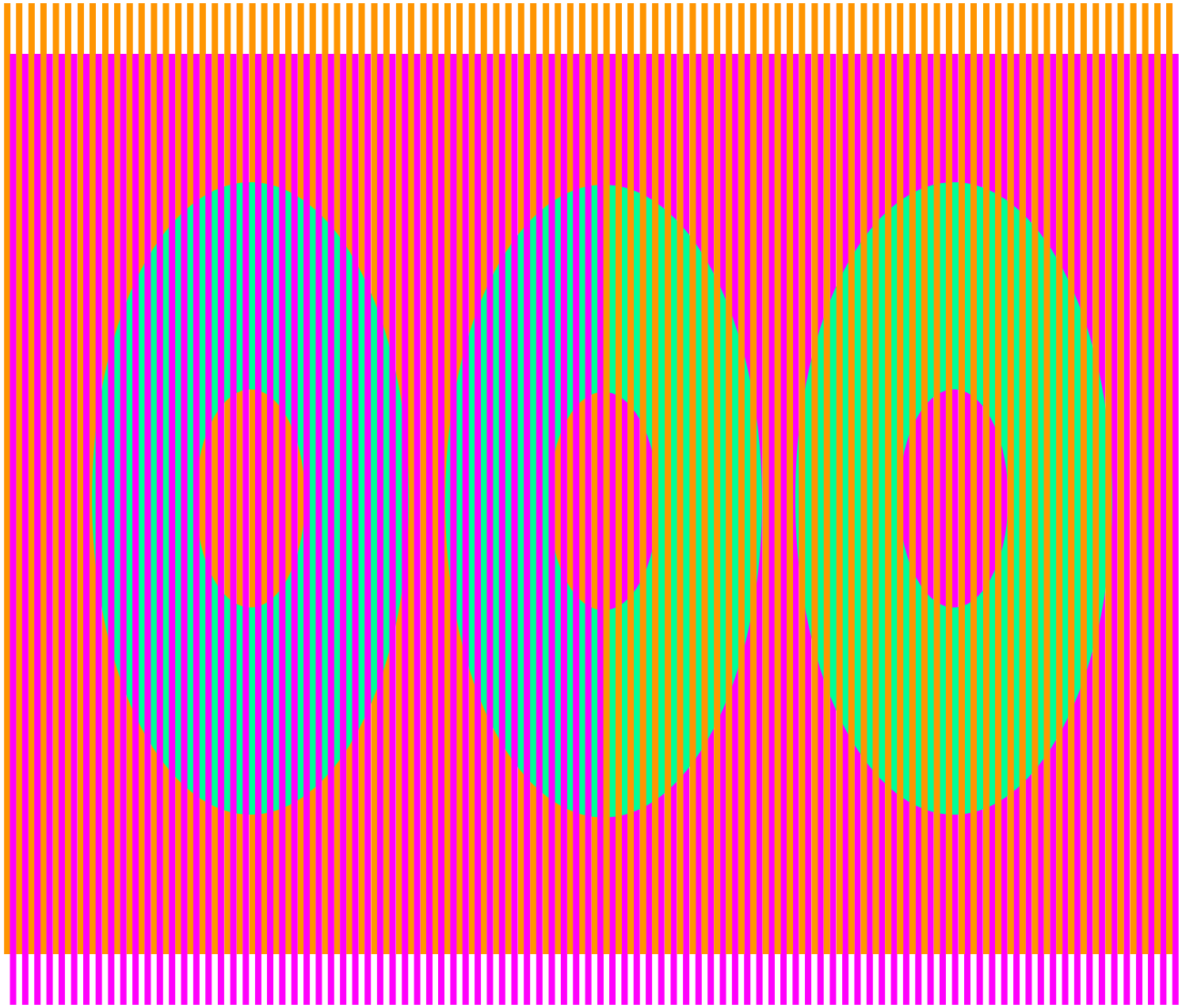


two tables

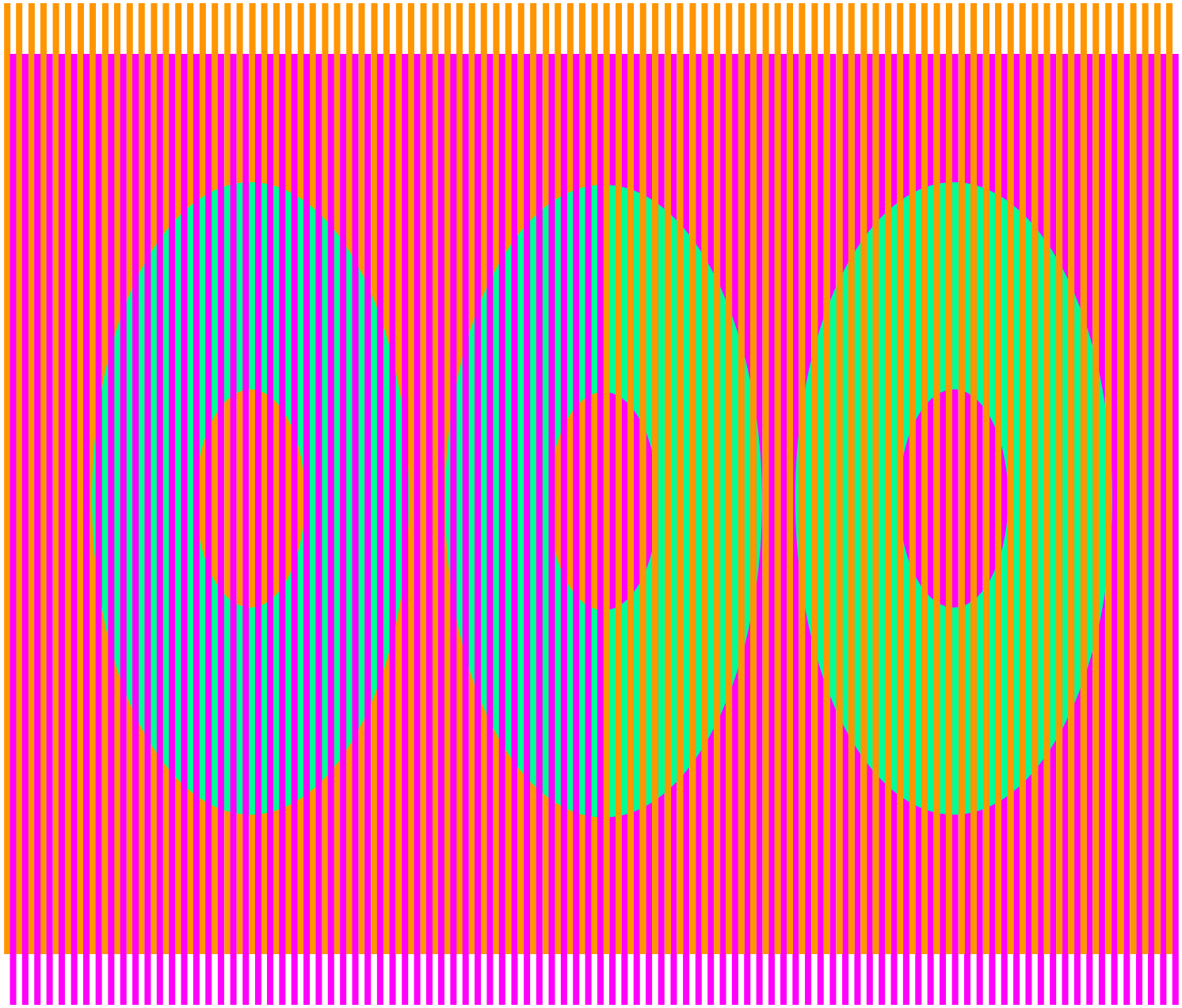


two segments

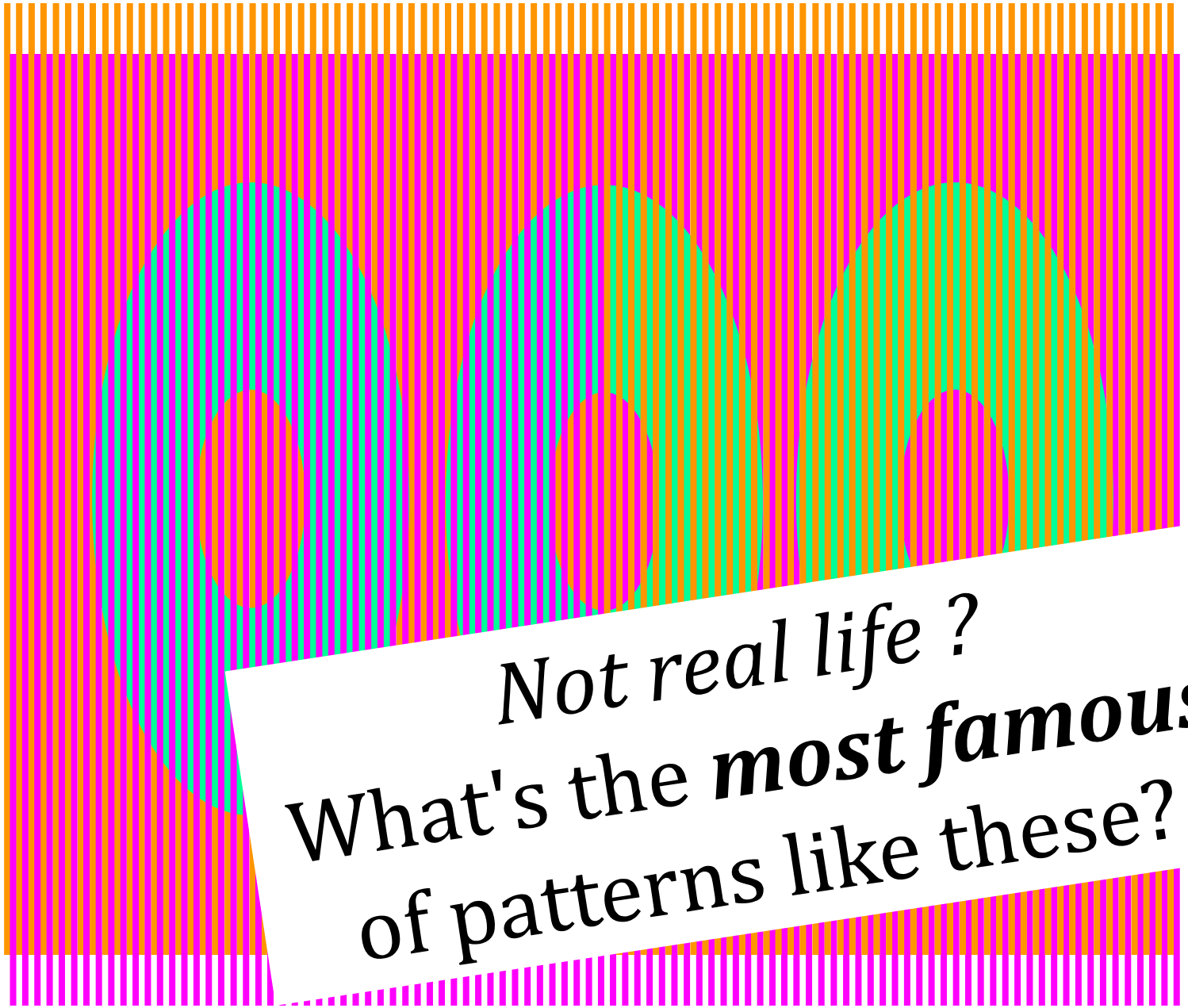
we don't always give our own vision system credit for ***all the work*** it's doing...



we don't always give our own vision system credit for ***all the work*** it's doing...



we don't always give our own vision system credit for ***all the work*** it's doing...



the now-familiar striped dress… !

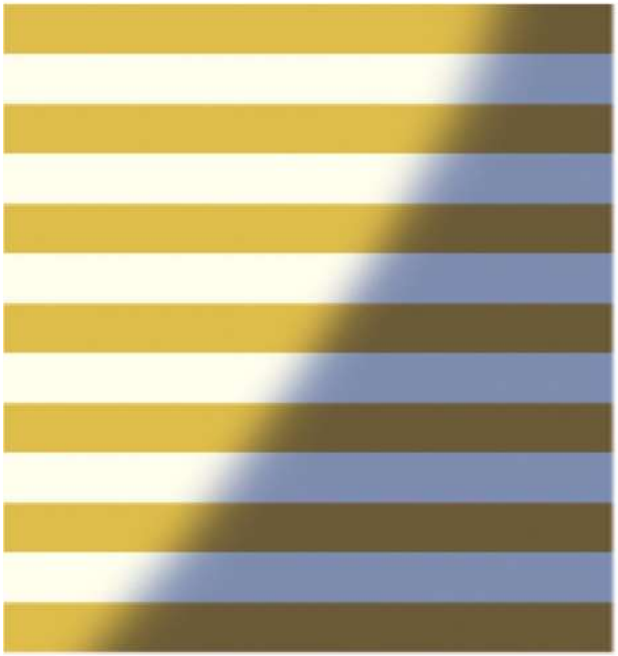
blue + black

vs.

white + gold

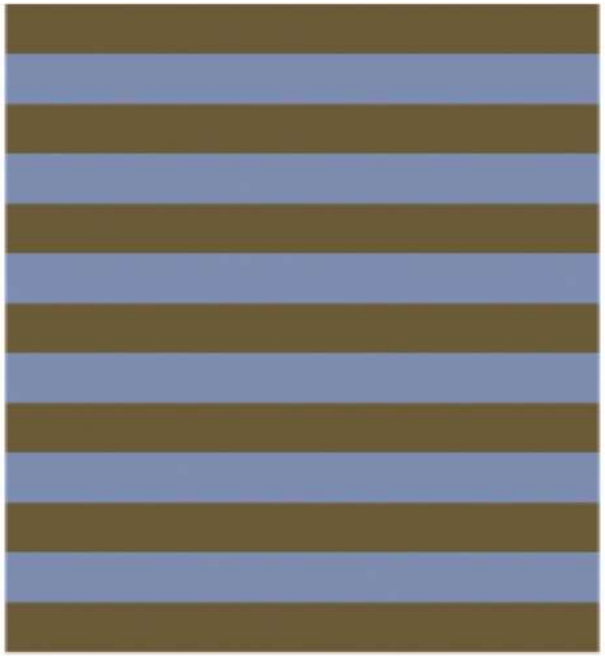
IS THE DRESS IN SHADOW?

If you think the dress is in shadow, your brain may remove the blue cast and perceive the dress as being white and gold.



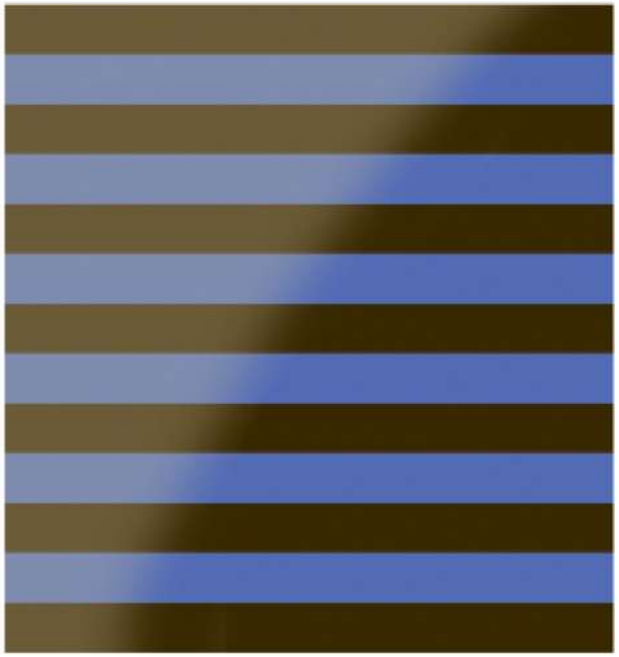
THE DRESS IN THE PHOTO

If the photograph showed more of the room, or if skin tones were visible, there might have been more clues about the ambient light.



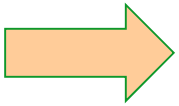
IS THE DRESS IN BRIGHT LIGHT?

If you think the dress is being washed out by bright light, your brain may perceive the dress as a darker blue and black.



NYT...

Let it go!



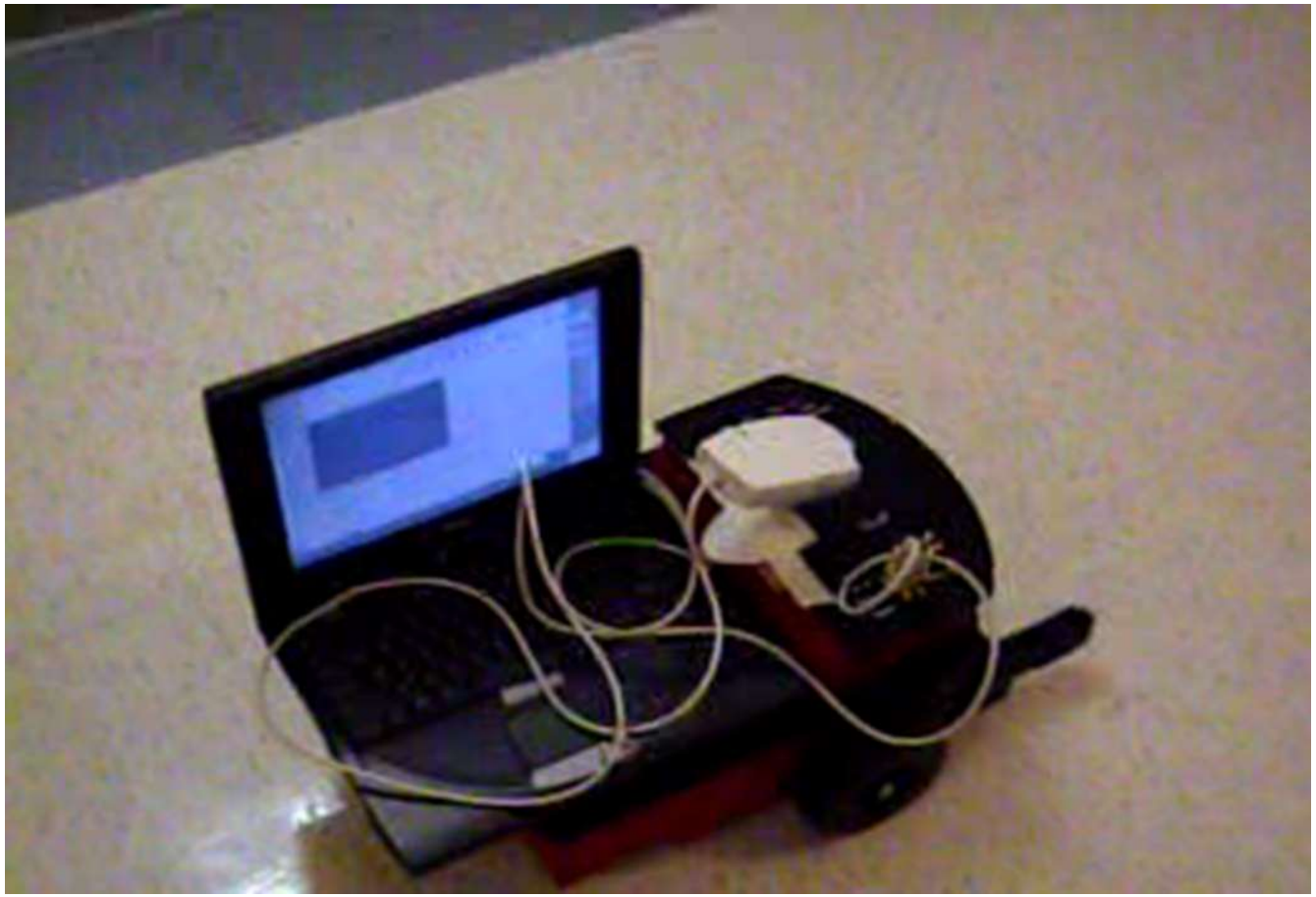
Aargh!

| hue | < 25

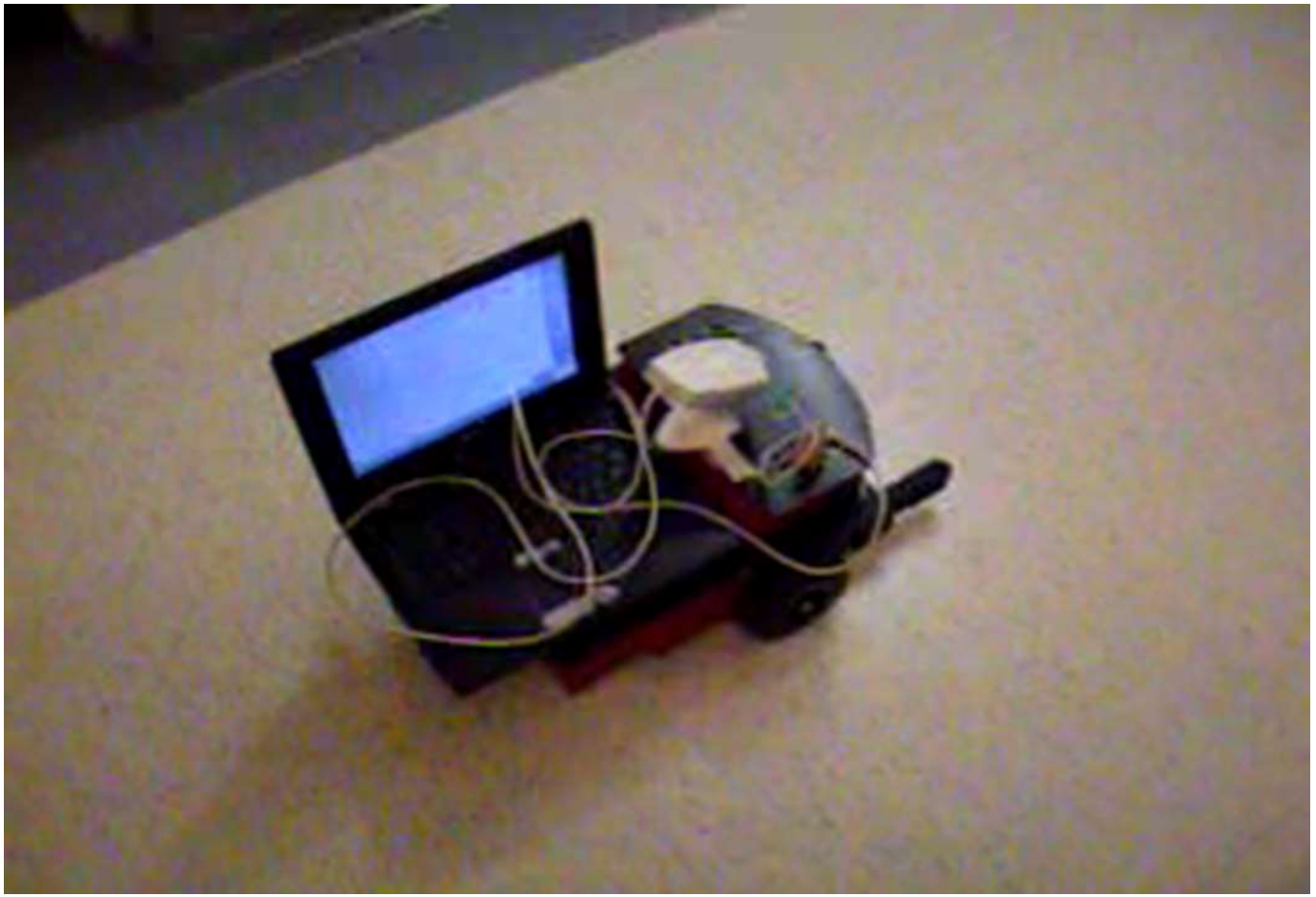
saturation > 0.75

Door == coke can? *We'll work around it!*

The coke-can collector: ***seeking...***



The coke-can collector: ***seeking...***



The coke-can collector: ***success!***

so many pixels!

Actual output: ***contents***

people, walking…

Computer Vision fail...

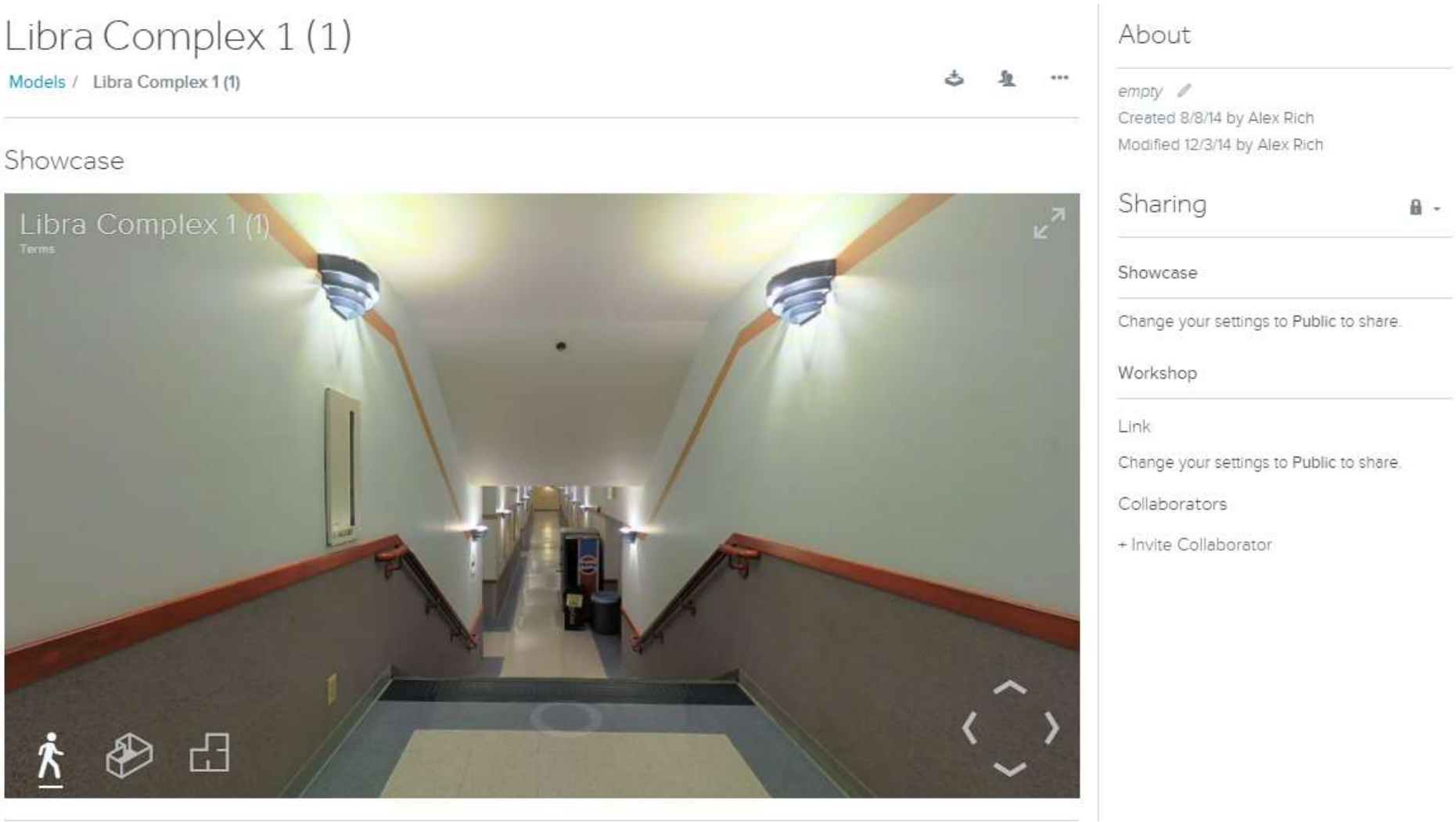
vs. Diversity fail !

Computer Vision is unusual...

How good is CV on *inanimate* things?

with human help, pretty good!

How good is CV on *inanimate* things?



CS 5: the past…

Functions & variables

Recursion

Representations (binary, ascii)

Circuit design & Hmmm

Loops, 2d arrays

Dictionaries

Objects and Classes

Computability

growing trees

looks like broccoli to me!

Caesar cipher

4-bit multiplier

Mandelbrot, Life

Markov Text Gen.

Date, C4, Project

Finite state machines

Uncomputable functions

CS 5: the past…

Functions & variables

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Loop

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looks like
broccoli to me!

Future CS?

ltiplier

Mandelbrot, Life

Markov Text Gen.

Date, C4, Project

Finite state machines
Uncomputable functions

Interfaces — *User Interfaces, Graphics, Animation*

CS 124, 155, 157

AI — *AI, Neural Networks, Computer Vision, Robotics*

CS 151, 152, 153, 154

Systems — *Compilers, Programming Languages, Networking, Operating Systems, Computer Archite*

Eng 85, 155, 158 & CS 125, 131, 13

Theory — *Theory of Computation, A*

Math 167, 168 & CS

Other CS courses?

SW Engineering & *Data structures*

CS 70, 121

Logic & Computability

CS 81

Principles of CS

CS 60

Interfaces

User I… …imation

Beyond classes?

…ks, Computer Vision, Robotics

CS 151, 152, 153, 154

Systems

Compilers, Programming Languages, Networking,
Operating Systems, Computer Archite…

Eng 85, 155, 158 & CS 125, 131, 13…

Other CS courses?

Theory

Theory of Computation, A…

Math 167, 168 & CS…

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CS 70, 121

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CS 60

Interfaces

User I… …imation

Beyond classes?

…ks, Computer Vision, Robotics

System

Theor

SW

D

CS 7

Dictionaries and list of lists Inbox x

Nathan Falk <nathan.falk@gmail.com> Mar 13

to Zachary

Professor Dodds,

I hope you're having a great semester so far and have a fun spring break planned!

I never thought I'd say this, but thank you so m… …or forcing us to learn all of the different data structures in your CS5 class l… …ear. A lot of my day today was spent deciding whether list of lists or dictionaries were more appropriate structures for a dataset I'm building (and I'm not even a programmer, so tell your students that saying they want to go into consulting isn't an excuse anymore)!

Regardless, it reminded me of the three-eyed alien.

I hope all is well,
Nathan


However you're CSing, enjoy!
6/28 3:18:53
but what if I'm nostalgic for CS 5 itself ?


However you're CSing, enjoy!
consider ***grutoring*** for CS5 next term or beyond...
but what if I'm nostalgic for CS 5 itself ?
6/28 3:18:53

Parting thought:

No matter *what* path you choose,
it's likely to be in binary…

Thank you for joining CS5!

Good luck on all finals (projects, exams, papers…)

Final Projects: due ***Friday*** evening…

Exam: Mon, **12/12** @ 7pm or Tue, **12/13** all day

Here in Shan 1430 HMC Green Room

REVIEW: Optional review session covering the practice final and any other questions…

Sunday evening, **12/11 7-8 pm** Shan B460