COMPUTER SCIENCE

LESSON 14+15, TUESDAY OCT 31ST +THURSDAY NOV 2ND

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THIS WEEK IN CS AND STEM

- Robot granted citizenship in Saudi Arabia
  - https://futurism.com/for-the-first-time-ever-a-robot-was-granted-citizenship/
- STEM cell healing project approved for human testing
  - https://futurism.com/stem-cell-wound-healing/

TYPE CONVERSION

- We've learned how to put representations into the print function for output (ex. repr(5)), but this is just the surface of type conversion.
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- What types of data have we learned about so far?
  - String
  - Integer
  - Float
  - boolean

TYPE CONVERSION CONT

- There are methods for converting each of these data types into each other, and you may need to do this conversions for different reasons. The most common is to convert floats and ints into strings for printing, but this is certainty not the only usage.
  - int()
  - float()
  - bool()
  - str()
- You can find the type of a variable by using type(). What might this be useful for?

TYPE CONVERSION CONT

- Now we know how to switch back and forth between types, and what works and what doesn't for these conversions. But sometimes our code will convert automatically to other types.

LIMITATIONS OF FINITE DATA REPRESENTATION

- You may have noticed when converting floats to ints that there was rounding involved, and it wasn't necessarily intuitive.
- There are also issues that arise due to fine data representation in coding as well, and it's not limited to python but an issue with computers in general – they're not infinitely accurate!

LIMITATIONS OF FINITE DATA REPRESENTATION

- We've learned that computers store information as a sequence of binary numbers (ie. base 2). All information is stored in this way, including integers and floating point numbers. But how are they represented in binary, and what's the limit for how many bits a number can occupy?

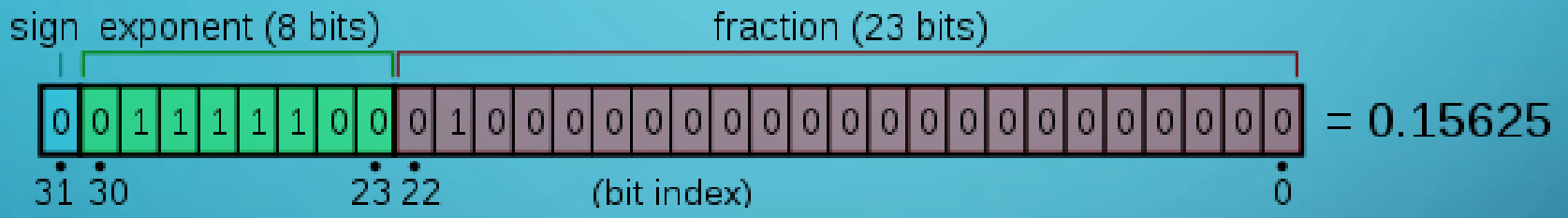
LIMITATIONS OF FINITE DATA REPRESENTATION

- We've learned that computers store information as a sequence of binary numbers (ie. base 2). All information is stored in this way, including integers and floating point numbers. But how are they represented in binary, and what's the limit for how many bits a number can occupy?
  - Single vs double precision (32 vs 64 bit numbers)
  - Typically numbers are stored as single precision*
  - Largest integer: $2^{31} - 1 = 2{,}147{,}483{,}647$ (ie. 32 bits that all have value 1)
  - Largest float: $(2 - 2^{-23}) \times 2^{127} \approx 3.402823 \times 10^{38}$, but how?

*We'll learn later that there are some Python functions that automatically use double precision floats!

LIMITATIONS OF FINITE DATA REPRESENTATION

- There are 3 parts to a float: the sign, the exponent, and the fraction.



- The sign indicates the sign of the float, and the exponent is the power of 2 that the entire float is multiplied by. The fraction is a little harder, where each bit is now $\frac{1}{2}^{\text{bitvalue}}$. Other ways to write this include:
  - $(-1)^{b_{31}} \times (1.b_{22}b_{21}\ldots b_0)_2 \times 2^{(b_{30}b_{29}\ldots b_{23})_2 - 127}$
  - $(-1)^{sign} \times (1 + \sum_{i=1}^{23} b_{23-i}2^{-i} \times 2^{e-127})$

LIMITATIONS OF FINITE DATA REPRESENTATION

- What are some issues with this representation for floating point numbers?

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- What are some issues with this representation for floating point numbers?
  - The primary is that many floats cannot be represented as a combination of finite binary fractions. This means that many of the fraction (and hence the whole float) is often approximated in machine memory – which leads to loss of accuracy.
  - This also means that some floats that are close together may also be represented by the same binary fraction and exponent
  - Python typically will display a rounded value, and usually only displays the first 12 decimal places if necessary.
    - Note that repr() and str() will round differently. Repr() will keep all of the decimal places you specify (so 17 usually), while str() will reduce the rounding to 12 decimal places!
  - Let's take a look at this using the decimal package.

ASSIGNMENT #4 = PROJECT 1

- 2 parter, code and short report (no refs necessary)

- Follow the instructions in Assignment4.ipynb and Assignment4.py. You'll need to submit both files plus a report document for full credit.
- Due Nov 5th by 11:59pm via email submission to woodford@cita.utoronto.ca

REFERENCES

- https://docs.scipy.org/doc/numpy-1.13.0/user/basics.types.html
- https://docs.python.org/3/library/functions.html
- https://docs.python.org/3.4/tutorial/floatingpoint.html
- https://docs.python.org/3/library/decimal.html
- http://www.lahey.com/float.htm