CECS 451
Assignment 5
Total: 50 Points

General Instruction

- Submit **uncompressed** file(s) in the Assignment folder via Canvas (Not email)
- Use **Python 3**, any other programming language is not acceptable
- You can import modules in the **Python Standard Library** (please check the full list here)

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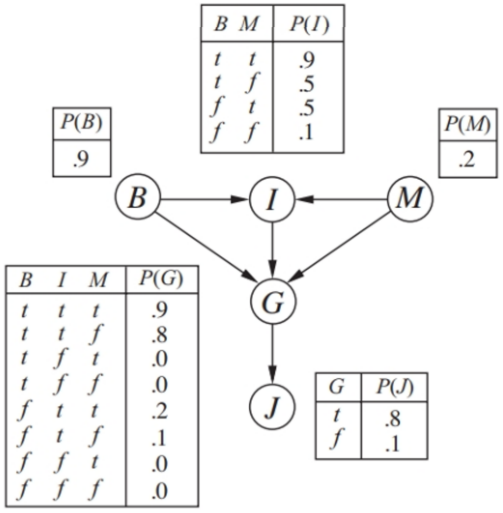
1. Given the full joint distribution shown in Figure 1, calculate the following:
   a. (2 points) $P(toothache)$
   b. (3 points) $\boldsymbol{P}(Cavity)$
   c. (3 points) $\boldsymbol{P}(Toothache|cavity)$

Figure 1.

	toothache		¬*toothache*	
	catch	¬*catch*	*catch*	¬*catch*
cavity	0.108	0.012	0.072	0.008
¬*cavity*	0.016	0.064	0.144	0.576

2. Consider the Bayes net shown in Figure 2, calculate the following:
   a. (5 points) $P(b, i, \neg m, g, j)$
   b. (6 points) $\boldsymbol{P}(J|b, i, m)$
   c. (6 points) $\boldsymbol{P}(J|\neg b, \neg i, m)$

Figure 2.



3. (25 points) Implement a program to **estimate π** using the Monte Carlo simulation method
   a. The program should generate n random points of (x, y)

      where $0 \le x < 1$ and $0 \le y < 1$ for $n \in \{10^3, 10^4, 10^5, 10^6\}$

   b. You can use `math.pi` to compute error rates
   c. Please follow this output format:

```
n = 10^3: pi = 3.096000 & error = 1.4513%
n = 10^4: pi = 3.136800 & error = 0.1526%
n = 10^5: pi = 3.145280 & error = 0.1174%
n = 10^6: pi = 3.140568 & error = 0.0326%
```

*Note that the estimated π and the error rates may be different (Fix precision using "0:.nf".format)

You can use the formula $error(\%) = |\frac{\pi - \pi'}{\pi}| \times 100,$ where π′ is the estimation

   d. For $n = 10^4$, draw a scatter plot as Figure 1, i.e., blue color for dots whose distances from the origin (0, 0) are less than 1, otherwise red color.
   e. Submit `pi.ipynb`

`Example:`

```
n = 10^3: pi = 3.256000 & error = 3.6417%
n = 10^4: pi = 3.137200 & error = 0.1398%
n = 10^5: pi = 3.142640 & error = 0.0333%
n = 10^6: pi = 3.141080 & error = 0.0163%
```