FIRST AND SECOND DERIVATIVE OF A GIVEN TABULAR DATA

February 8, 2021

1 First and second derivatives

The derivative of a function $f(x)$ at $x = a$ is the limit

$$f^{'}(a) = \lim_{h \to 0} \frac{f(a+h) - f(a)}{h}$$

Difference formula

There are 3 main difference formulas for numerically approximating derivatives.

The forward difference formula with step size h is

$$f^{'}(a) \approx \frac{f(a+h) - f(a)}{h}$$

The backward difference formula with step size $h $ is

$$f^{'}(a) \approx \frac{f(a) - f(a-h)}{h}$$

The central difference formula with step size h is the average of the forward and backwards difference formulas

$$f^{'}(a) \approx \left(\frac{f(a+h) - f(a)}{h} + \frac{f(a) - f(a-h)}{h} \right)$$

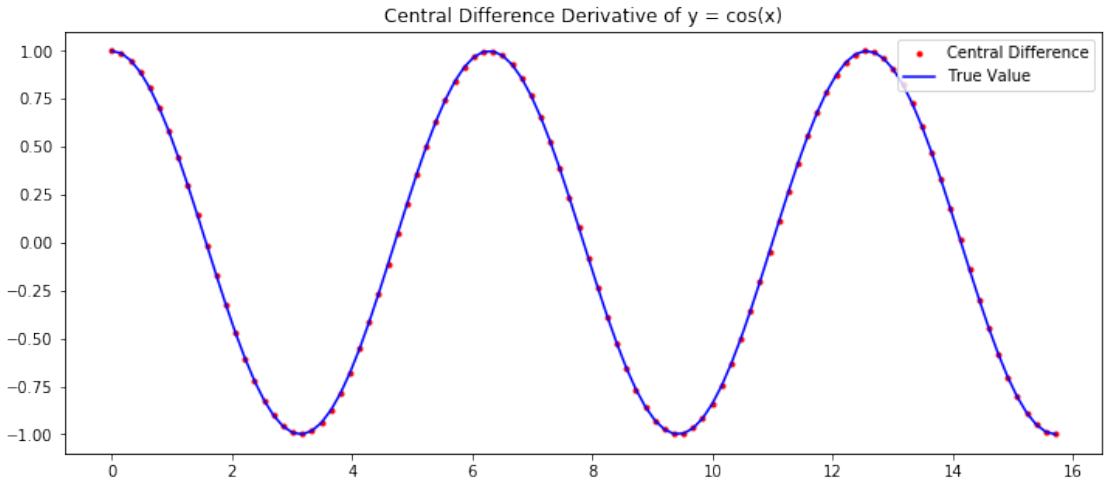
To calculate the first and second derivative of the tabular values, let's define a function called derivative. which takes input parameters f, a, method and h (with default values method='central' and h=0.01) and returns the corresponding difference formula for $f^{'}(a) $ with step size h.

```
In [1]: import numpy as np
        import matplotlib.pyplot as plt
        %matplotlib inline
```

```
In [2]: def derivative(f,a,method='central',h=0.01):
            '''Compute the difference formula for f'(a) with step size h.

            Parameters
            ----------
            f : function
                Vectorized function of one variable
```

```
        a : number
            Compute derivative at x = a
        method : string
            Difference formula: 'forward', 'backward' or 'central'
        h : number
            Step size in difference formula

        Returns
        -------
        float
            Difference formula:
                central: f(a+h) - f(a-h))/2h
                forward: f(a+h) - f(a))/h
                backward: f(a) - f(a-h))/h
        '''
        if method == 'central':
            return (f(a + h) - f(a - h))/(2*h)
        elif method == 'forward':
            return (f(a + h) - f(a))/h
        elif method == 'backward':
            return (f(a) - f(a - h))/h
        else:
            raise ValueError("Method must be 'central', 'forward' or 'backward'.")
```

In [6]:
```
x = np.linspace(0,5*np.pi,100)
dydx = derivative(np.sin,x)
#print(x)
#print(dydx)
dYdx = np.cos(x)
d2ydx = derivative(np.cos,x)
#print(d2ydx)
plt.figure(figsize=(12,5))
plt.plot(x,dydx,'r.',label='Central Difference')
plt.plot(x,dYdx,'b',label='True Value')

plt.title('Central Difference Derivative of y = cos(x)')
plt.legend(loc='best')
plt.show()
```



2 References

1. https://www.math.ubc.ca/~pwalls/math-python/differentiation/differentiation/

2 . https://www.youtube.com/watch?v=SFI_l96Oss4

3. https://www.youtube.com/watch?v=f31LNHPUqb4

In [ ]: