ASSIGNMENT 3 REPORT

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I. Contributions

- Qiao Leiying: UI design, merge code, American option
- Zhang Mengshu: European option, Implied volatility, Geometric Asian/basket option
- Zhu Qingyu: Merge report, Arithmetic Asian option, Arithmetic basket option

II. Functionalities Test and Analysis

Task 1. European call/put options:

- *price_call(S,K,r,q,sigma,tau)*: calculate the call option price use Black-Scholes formulas
- *price_put(S,K,r,q,sigma,tau):* calculate the put option price use Black-Scholes formulas

Table 1 and Table 2 list the test results and analysis results, respectively. Where S=100, K=100, r=1%, σ =20%, T=0.5:

Table 1 European Option Test

q	Option Type	Price
5%	C	4.62
3%	C	5.10
5%	P	6.59
3%	P	6.09

Table 2 Parameter Analysis

Parameter \ Option Type	Call	Put
q ↑	↓	↑

Task 2. Implied volatility calculator:

- *vega(S,K,r,q,sigma,tau):* calculate $\frac{\partial C(\sigma)}{\partial \sigma}$ and $\frac{\partial P(\sigma)}{\partial \sigma}$
- *v_call(S,r,q,tau,K,C_true):* calculate the implied volatility of call option
- *v_put(S,r,q,tau,K,P_true):* calculate the implied volatility of put option

Task 3. Geometric Asian options & Geometric basket options:

- *geometric_Asian_call_option(S,sigma,r,T,K,n):* calculate the geometric Asian call option price
- *geometric_Asian_put_option(S,sigma,r,T,K,n):* calculate the geometric Asian call option price

Table 3 and Table 2 respectively list the test and analysis results of geometric Asian option function. Where S=100, r=0.05, T=3, K=100:

Table 3 Geometric Asian Option Test

σ	n	Option Type	Geometric Price
0.3	50	C	13.26
0.3	100	C	13.14
0.4	50	C	15.76
0.3	50	P	8.48
0.3	100	P	8.43
0.4	50	P	12.56

Table 4 Parameter Analysis

Parameter \ Option Type	Call	Put
σ ↑	↑	↑
n ↑	↓	↓

- *geometric_basket_call_option(S1, S2,sigma1,sigma2,r,T,K,rou):* calculate the geometric basket call option price
- *geometric_basket_put_option(S1, S2,sigma1,sigma2,r,T,K,rou):* calculate the geometric basket put option price

Table 5 and Table 6 respectively list the test and analysis results of geometric basket option function. Where S1=100, S2=100, r=0.05, T=3:

Table 5 Basket Option Test

σ 1	σ 2	K	ρ	Option Type	Geometric Price
0.3	0.3	100	0.5	C	22.10
0.3	0.3	100	0.9	C	25.88
0.1	0.3	100	0.5	C	17.92
0.3	0.3	80	0.5	C	32.54
0.3	0.3	120	0.5	C	14.69
0.5	0.5	100	0.5	C	28.45
0.3	0.3	100	0.5	P	11.49
0.3	0.3	100	0.9	P	12.62
0.1	0.3	100	0.5	P	6.59
0.3	0.3	80	0.5	P	4.71
0.3	0.3	120	0.5	P	21.29
0.5	0.5	100	0.5	P	23.47

Table 6 Parameter Analysis

Parameter \ Option Type	Call	Put
σ 1 ↑	↑	↑
σ 1 & σ 2 ↑	↑	↑
K ↑	↓	↑
ρ ↑	↑	↑

Task 4. Arithmetic Asian call/put options:

- *ArithmeticAsianOptionMC(T, K, n, S, r, sigma, option_type, NumPath, cv):* Calculate the arithmetic Asian call/ put option by MC without/with control variate(cv).

Table 7 and Table 8 respectively list the test case and analysis results of this function. Where S=100, r=0.05, T=3, K=100, NumPath=100000:

Table 7 Arithmetic Asian Option from MC with/without CV

σ	n	Option Type	Standard MC		MC with Control	
			Option Price	Confidence interval	Option Price	Confidence interval
0.3	50	C	14.69128	[14.54797, 14.83459]	14.73451	[14.72231, 14.74672]

0.3	100	C	14.62305	[14.48148, 14.76463]	14.60831	[14.59617, 14.62045]
0.4	50	C	18.15721	[17.95654, 18.35787]	18.21658	[18.19461, 18.23856]
0.3	50	P	7.79102	[7.72208, 7.85996]	7.80180	[7.79642, 7.80718]
0.3	100	P	7.76264	[7.69379, 7.83148]	7.75481	[7.74954, 7.76009]
0.4	50	P	11.27771	[11.18799, 11.36744]	11.28486	[11.27478, 11.29493]

Table 8 Parameter Analysis for Arithmetic Asian Options

Parameter \ Option Type	Call	Put
σ ↑	↑	↑
n ↑	↓	↓

Task 5. Arithmetic basket call/put options:

- *ArithmeticBasketOptionMC(T, K, S1, S2, r, sigma1, sigma2, rou, option_type,NumPath, cv):* Calculate the arithmetic basket call/ put option by MC without/with control variate(cv)

Table 9 and Table 10 respectively list the test and analysis results of this function. Where S1=100, S2=100, r=0.05, T=3, NumPath=100000:

Table 9 Arithmetic Basket Option from MC with/without CV

σ 1	σ 2	K	ρ	Option Type	Standard MC		MC with Control	
					Option Price	Confidence interval	Option Price	Confidence interval
0.3	0.3	100	0.5	C	24.53988	[24.29826, 24.78149]	24.49885	[24.46784, 24.52986]
0.3	0.3	100	0.9	C	26.331	[26.05548, 26.60651]	26.35458	[26.34824, 26.36091]
0.1	0.3	100	0.5	C	19.53876	[19.36552, 19.71201]	19.44502	[19.42586, 19.46418]
0.3	0.3	80	0.5	C	35.47778	[35.20851, 35.74705]	35.38138	[35.34933, 35.41342]
0.3	0.3	120	0.5	C	16.58558	[16.37569, 16.79547]	16.58853	[16.55922, 16.61784]
0.5	0.5	100	0.5	C	34.99235	[34.52049, 35.46421]	34.98858	[34.88320, 35.09395]
0.3	0.3	100	0.5	P	10.49475	[10.40059, 10.58891]	10.57781	[10.56571, 10.58992]
0.3	0.3	100	0.9	P	12.34033	[12.23540, 12.44526]	12.42732	[12.42458, 12.43006]
0.1	0.3	100	0.5	P	5.48395	[5.42696, 5.54094]	5.52177	[5.51328, 5.53025]
0.3	0.3	80	0.5	P	4.21849	[4.16347, 4.27351]	4.24983	[4.24213, 4.25754]
0.3	0.3	120	0.5	P	19.75461	[19.62118, 19.88805]	19.87943	[19.86312, 19.89574]
0.5	0.5	100	0.5	P	20.94084	[20.79480, 21.08688]	21.07868	[21.05053, 21.10683]

Table 10 Parameter Analysis for Arithmetic Basket Option

Parameter \ Option Type	Call	Put
σ 1 ↑	↑	↑
σ 1 & σ 2 ↑	↑	↑
K ↑	↓	↑
ρ ↑	↑	↑

Task 6. American call/put options:

- *Binomial_tree(S,K,r,sigma,T,N,type):* This is for American option with N - steps. Mainly use 'For' loop to calculate the stock price and option price starting from the leaf nodes to root. Return the option price of the root.

Table 11 and Table 12 list the test results and analysis results of this function, respectively. Where steps= 3:

Table 11 American Option Test

S	sigma	T	K	r	Option Type	Price
50	0.3	0.25	50	0.05	C	3.54140
60	0.3	0.25	50	0.05	C	11.07462
50	0.5	0.25	50	0.05	C	5.67543
50	0.3	0.5	50	0.05	C	5.16291
50	0.3	0.25	60	0.05	C	0.60552
50	0.3	0.25	50	0.08	C	3.72546
50	0.3	0.25	50	0.05	P	2.97133
60	0.3	0.25	50	0.05	P	0.45351
50	0.5	0.25	50	0.05	P	5.11041
50	0.3	0.5	50	0.05	P	4.02900
50	0.3	0.25	60	0.05	P	10.16876
50	0.3	0.25	50	0.08	P	2.81189

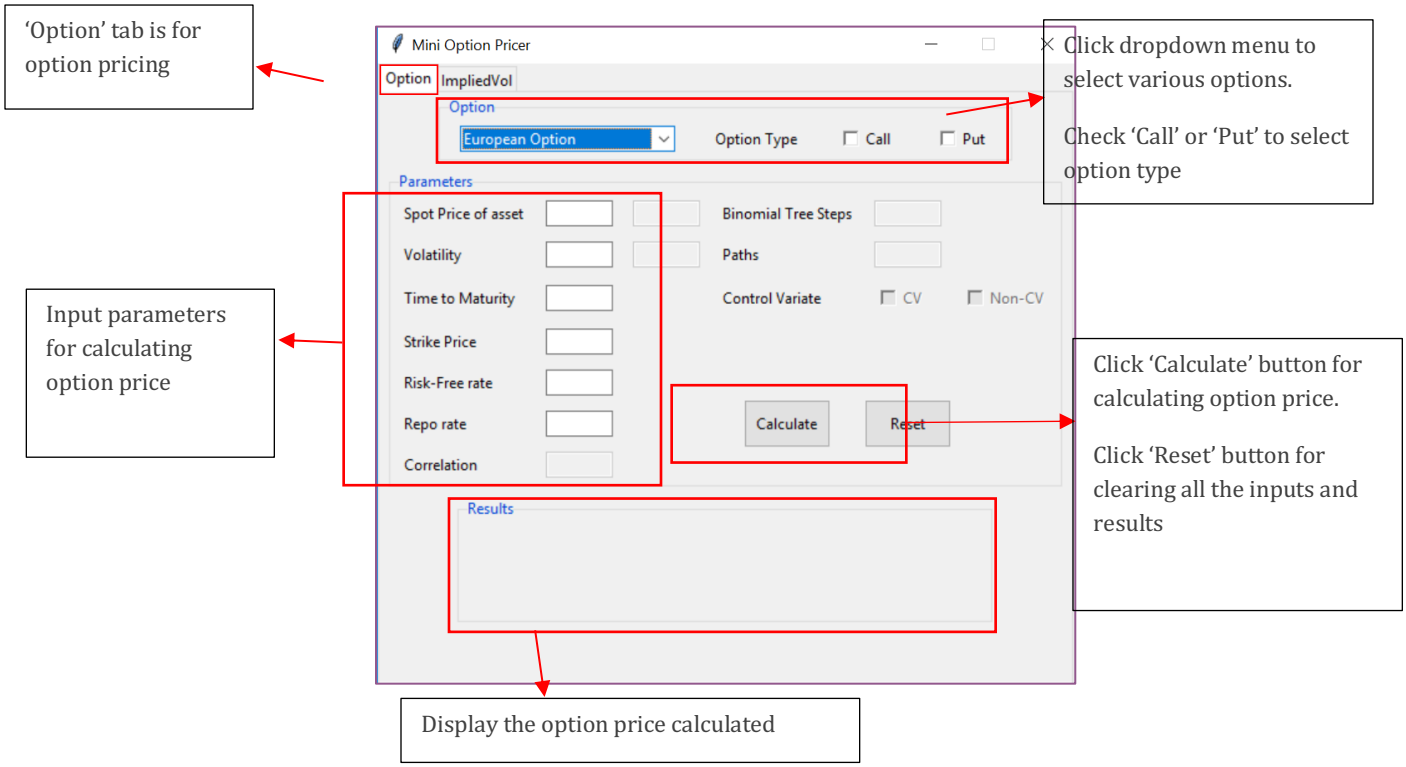
Table 12 Parameter Analysis for American Option

Option Type / Parameters	Call	Put
Stock price↑	↑	↓
Sigma↑	↑	↑
Maturity↑	↑	↑
Strike↑	↓	↑
Risk Free Rate↑	↑	↓

III. User Interface

- **Option pricing:**

Step1: choose the tab 'Option' (default)



- **Implied Volatility Calculator:**