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| Кафедра прикладной математики | | |
| Практическое задание № 3 | | |
| по дисциплине «Численные методы» | | |
| РЕШЕНИЕ РАЗРЕЖЕННЫХ СЛАУ ТРЕХШАГОВЫМИ ИТЕРАЦИОННЫМИ МЕТОДАМИ С ПРЕДОБУСЛОВЛИВАНИЕМ | | |
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| Новосибирск, 2023 | | |

1. **Задание**

Изучить особенности реализации трехшаговых итерационных методов для СЛАУ с разреженными матрицами. Исследовать влияние предобусловливания на сходимость изучаемых методов на нескольких матрицах большой (не менее 10000) размерности.

1. **Математическая модель**

Алгоритм метода сопряженных градиентов для системы уравнений с несимметричной матрицей А:



Заключается в симметризации СЛАУ следующим образом:



Тогда начальное приближение выбирается следующим образом:





Далее для  производятся следующие вычисления:











где  - вектор начальное приближения; - вектор решения на -й (текущей итерации); - вектор невязки на -й (текущей) итерации; - вектор спуска (сопряженное направление) на -й итерации;  - коэффициенты.

Выход из итерационного процесса осуществляется либо по условию малости относительной невязки



Для ускорения сходимости итерационных методов обычно используют предобусловливание матрицы системы. Одним методов предобусловливания является метод **неполной факторизации.** Рассмотрим процедуру для предобусловленной СЛАУ , построенную на основе метода сопряженных градиентов. Итак вместо исходной СЛАУ  будем решать СЛАУ , в которой



Где матрицы  и  соответственно нижняя треугольная и верхнетругольная матрицы неполной факторизации исходной матрицы .

Тогда формулы метода сопряженных градиентов преобразуются к следующему виду:

Выбирается начальное приближение и полагается













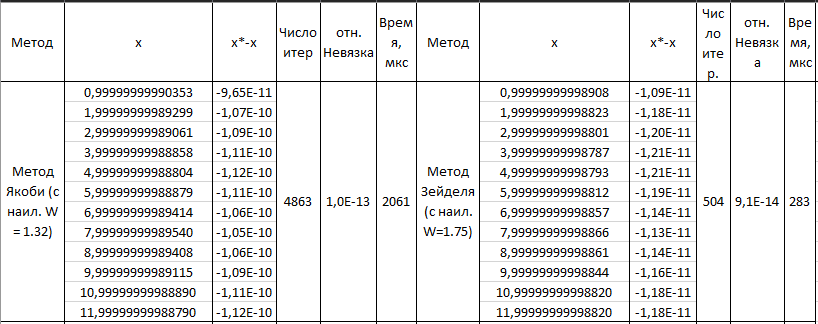


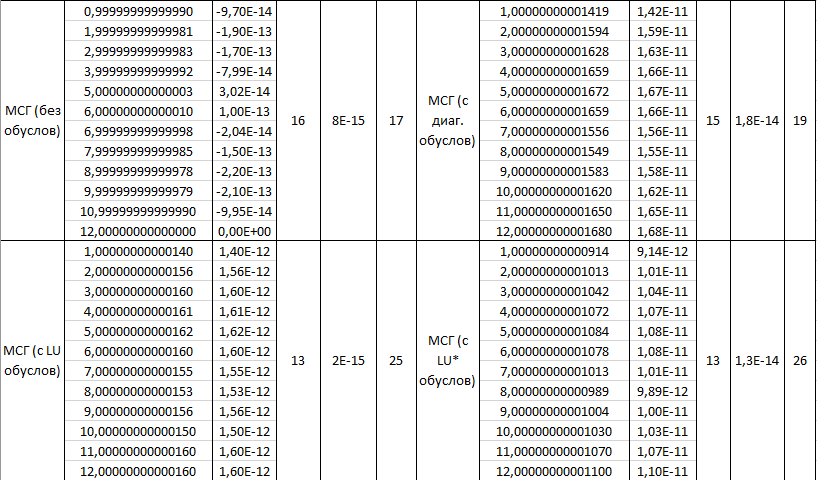
По окончании итерационного процесса вектор решения вычисляется следующим образом:

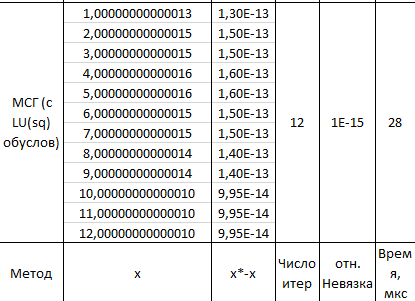


1. **Исследование матриц с регулируемым числом обусловленности**

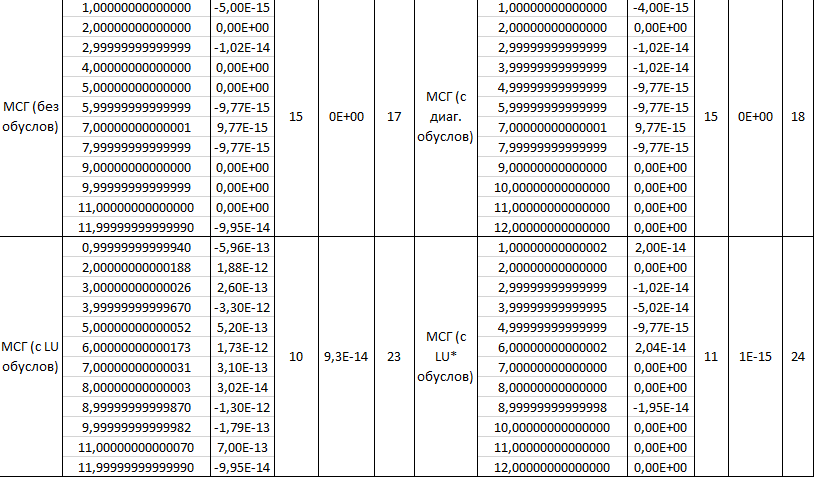
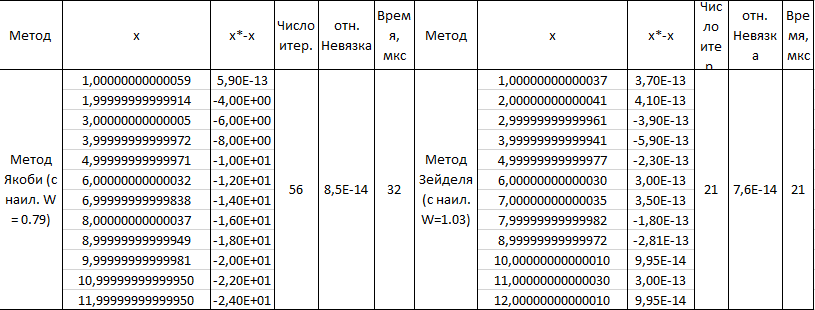
****

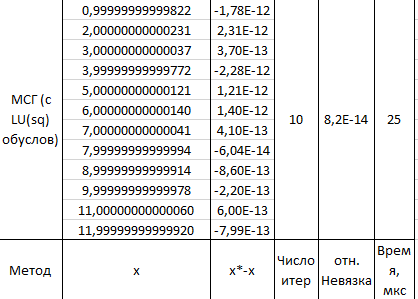












**Приложение**

**SLAE.h**

#pragma once

#pragma once

#include <cstdio>

#include <math.h>

#define REALOUTD "%.7f\t"

class SLAE {

public:

int n, maxiter = 10000, nProfile = 0;

double eps = 1e-13;

double\* al, \* au, \* di;

double\* alLU, \* auLU, \* diLU;

double\* x, \* x0, \* b, \* xtrue;

double\* r, \* z, \* tmp1;

int\* ia, \* ja;

void Input(FILE\* paramf, FILE\* iaf, FILE\* jaf, FILE\* alf, FILE\* auf, FILE\* dif, FILE\* bf);

void MatrixVectorMultiplication(double\* vectorMult, double\* vectorOut);

void TransposedMatrixVectorMultiplication(double\* vectorMult, double\* vectorOut);

double CalculateRelativeDiscrepancyWithR(double norm);

double CalculateRelativeDiscrepancy(double norm);

void MethodOfConjugateGradientsForSymMatrix();

void MethodOfConjugateGradientsForNonSymMatrix();

void MethodOfConjugateGradientsForSymMatrixWithDiagP();

void MethodOfConjugateGradientsForNonSymMatrixWithDiagP();

void MethodOfConjugateGradientsForSymMatrixWithLuP();

void MethodOfConjugateGradientsForNonSymMatrixWithLuP();

void MethodOfConjugateGradientsForNonSymMatrixWithLuAsterP();

void MethodOfConjugateGradientsForNonSymMatrixWithLuSqP();

void VectorConditionalityForSymMatrixDiagP(double\* vectorIn, double\* vectorOut);

void VectorConditionalityForNonSymMatrixDiagP(double\* vectorIn, double\* vectorOut);

void CalculateLU();

void CalculateLUaster();

void CalculateLUsq();

void GenerateHilbertMatrix(int size);

void SolveForward(double\* lowerTringMat, double\* diag, double\* rightVector, double\* vectorX);

void SolveBackward(double\* upperTringMat, double\* diag, double\* rightVector, double\* vectorX);

void SolveForwardLU(double\* lowerTringMat, double\* rightVector, double\* vectorX);

void SolveBackwardLU(double\* upperTringMat, double\* rightVector, double\* vectorX);

void SolveForwardLU(double\* lowerTringMat, double\* diag, double\* rightVector, double\* vectorX);

void SolveBackwardLU(double\* upperTringMat, double\* diag, double\* rightVector, double\* vectorX);

void MatrixUVectorMultiplicationLU(double\* U, double\* vectorMult, double\* vectorOut);

void CalculateZ\_LU(double\* vectorOut);

void CalculateZ\_LUaster(double\* vectorOut);

void CalculateZ\_LUsq(double\* vectorOut);

void CalculateFsubAx(double\* vectorMult, double\* vectorOut);

void VectorSubtract(double\* first, double\* second, double\* result);

double VectorScalarProduction(double\* vector);

double VectorScalarProduction(double\* vector1, double\* vector2);

double VectorNorm(double\* vector);

void VectorCopy(double\* first, double\* second);

void OutputDense();

void OutputLUDense();

void VectorOutputSolution(FILE\* out);

protected:

void AllocateMemory();

void ClearMemory();

};

SLAE.cpp

#include "slae.h"

void SLAE::Input(FILE\* paramf, FILE\* iaf, FILE\* jaf, FILE\* alf, FILE\* auf, FILE\* dif, FILE\* bf) {

fscanf\_s(paramf, "%d", &n);

fscanf\_s(paramf, "%d", &maxiter);

fscanf\_s(paramf, "%lf", &eps);

ia = new int[n + 1];

for (int i = 0; i <= n; i++)

fscanf\_s(iaf, "%d", &ia[i]);

nProfile = ia[n] - ia[0];

AllocateMemory();

for (int i = 0; i < nProfile; i++)

fscanf\_s(jaf, "%d", &ja[i]);

if (ia[0]) {

for (int i = 0; i <= n; i++)

ia[i]--;

for (int i = 0; i < nProfile; i++)

ja[i]--;

}

for (int i = 0; i < nProfile; i++)

fscanf\_s(alf, "%lf", &al[i]);

for (int i = 0; i < nProfile; i++)

fscanf\_s(auf, "%lf", &au[i]);

for (int i = 0; i < n; i++)

fscanf\_s(dif, "%lf", &di[i]);

for (int i = 0; i < n; i++)

fscanf\_s(bf, "%lf", &b[i]);

//for (int i = 0; i < n; i++)

// x0[i] = 0;

for (int i = 0; i < n; i++)

{

xtrue[i] = i + 1;

}

}

void SLAE::OutputDense()

{

int flagfound = 0;

for (int i = 0; i < n; i++)

{

int k = ia[i + 1] - ia[i];

if (k == 0)

{

for (int j = 0; j < i; j++)

{

printf(REALOUTD, 0.0);

}

}

else

{

int lastj = 0;

for (int j = ia[i]; j < ia[i + 1]; j++) //��� ��� 100 ���� ���������.

{

for (int p = lastj; p < ja[j]; p++) //��� ��� 100 ���� ���������.

{

printf(REALOUTD, 0.0);

}

printf(REALOUTD, al[j]);

lastj = ja[j] + 1;

}

for (int j = lastj; j < i; j++) //??

{

printf(REALOUTD, 0.0);

}

}

printf(REALOUTD, di[i]);

for (int j = i + 1; j < n; j++)

{

k = ia[j + 1] - ia[j];

if (k == 0) {

printf(REALOUTD, 0.0);

}

else

{

flagfound = 0;

for (k = ia[j]; k < ia[j + 1]; k++)

{

if (ja[k] == i)

{

printf(REALOUTD, au[k]);

flagfound = 1;

break;

}

}

if (flagfound == 0)

printf(REALOUTD, 0.0);

}

}

printf("\n");

}

printf("\n");

}

void SLAE::OutputLUDense()

{

int flagfound = 0;

for (int i = 0; i < n; i++)

{

int k = ia[i + 1] - ia[i];

if (k == 0)

{

for (int j = 0; j < i; j++)

{

printf(REALOUTD, 0.0);

}

}

else

{

int lastj = 0;

for (int j = ia[i]; j < ia[i + 1]; j++) //��� ��� 100 ���� ���������.

{

for (int p = lastj; p < ja[j]; p++) //��� ��� 100 ���� ���������.

{

printf(REALOUTD, 0.0);

}

printf(REALOUTD, alLU[j]);

lastj = ja[j] + 1;

}

for (int j = lastj; j < i; j++) //??

{

printf(REALOUTD, 0.0);

}

}

printf(REALOUTD, diLU[i]);

for (int j = i + 1; j < n; j++)

{

k = ia[j + 1] - ia[j];

if (k == 0) {

printf(REALOUTD, 0.0);

}

else

{

flagfound = 0;

for (k = ia[j]; k < ia[j + 1]; k++)

{

if (ja[k] == i)

{

printf(REALOUTD, auLU[k]);

flagfound = 1;

break;

}

}

if (flagfound == 0)

printf(REALOUTD, 0.0);

}

}

printf("\n");

}

printf("\n");

}

#include "slae.h"

void SLAE::Input(FILE\* paramf, FILE\* iaf, FILE\* jaf, FILE\* alf, FILE\* auf, FILE\* dif, FILE\* bf) {

fscanf\_s(paramf, "%d", &n);

fscanf\_s(paramf, "%d", &maxiter);

fscanf\_s(paramf, "%lf", &eps);

ia = new int[n + 1];

for (int i = 0; i <= n; i++)

fscanf\_s(iaf, "%d", &ia[i]);

nProfile = ia[n] - ia[0];

AllocateMemory();

for (int i = 0; i < nProfile; i++)

fscanf\_s(jaf, "%d", &ja[i]);

if (ia[0]) {

for (int i = 0; i <= n; i++)

ia[i]--;

for (int i = 0; i < nProfile; i++)

ja[i]--;

}

for (int i = 0; i < nProfile; i++)

fscanf\_s(alf, "%lf", &al[i]);

for (int i = 0; i < nProfile; i++)

fscanf\_s(auf, "%lf", &au[i]);

for (int i = 0; i < n; i++)

fscanf\_s(dif, "%lf", &di[i]);

for (int i = 0; i < n; i++)

fscanf\_s(bf, "%lf", &b[i]);

//for (int i = 0; i < n; i++)

// x0[i] = 0;

for (int i = 0; i < n; i++)

{

xtrue[i] = i + 1;

}

}

void SLAE::OutputDense()

{

int flagfound = 0;

for (int i = 0; i < n; i++)

{

int k = ia[i + 1] - ia[i];

if (k == 0)

{

for (int j = 0; j < i; j++)

{

printf(REALOUTD, 0.0);

}

}

else

{

int lastj = 0;

for (int j = ia[i]; j < ia[i + 1]; j++) //��� ��� 100 ���� ���������.

{

for (int p = lastj; p < ja[j]; p++) //��� ��� 100 ���� ���������.

{

printf(REALOUTD, 0.0);

}

printf(REALOUTD, al[j]);

lastj = ja[j] + 1;

}

for (int j = lastj; j < i; j++) //??

{

printf(REALOUTD, 0.0);

}

}

printf(REALOUTD, di[i]);

for (int j = i + 1; j < n; j++)

{

k = ia[j + 1] - ia[j];

if (k == 0) {

printf(REALOUTD, 0.0);

}

else

{

flagfound = 0;

for (k = ia[j]; k < ia[j + 1]; k++)

{

if (ja[k] == i)

{

printf(REALOUTD, au[k]);

flagfound = 1;

break;

}

}

if (flagfound == 0)

printf(REALOUTD, 0.0);

}

}

printf("\n");

}

printf("\n");

}

void SLAE::OutputLUDense()

{

int flagfound = 0;

for (int i = 0; i < n; i++)

{

int k = ia[i + 1] - ia[i];

if (k == 0)

{

for (int j = 0; j < i; j++)

{

printf(REALOUTD, 0.0);

}

}

else

{

int lastj = 0;

for (int j = ia[i]; j < ia[i + 1]; j++) //��� ��� 100 ���� ���������.

{

for (int p = lastj; p < ja[j]; p++) //��� ��� 100 ���� ���������.

{

printf(REALOUTD, 0.0);

}

printf(REALOUTD, alLU[j]);

lastj = ja[j] + 1;

}

for (int j = lastj; j < i; j++) //??

{

printf(REALOUTD, 0.0);

}

}

printf(REALOUTD, diLU[i]);

for (int j = i + 1; j < n; j++)

{

k = ia[j + 1] - ia[j];

if (k == 0) {

printf(REALOUTD, 0.0);

}

else

{

flagfound = 0;

for (k = ia[j]; k < ia[j + 1]; k++)

{

if (ja[k] == i)

{

printf(REALOUTD, auLU[k]);

flagfound = 1;

break;

}

}

if (flagfound == 0)

printf(REALOUTD, 0.0);

}

}

printf("\n");

}

printf("\n");

}

void SLAE::MatrixVectorMultiplication(double\* vectorMult, double\* vectorOut)

{

for (int i = 0; i < n; i++)

{

vectorOut[i] = di[i] \* vectorMult[i];

for (int k = ia[i]; k < ia[i + 1]; k++)

{

int j = ja[k];

vectorOut[i] += al[k] \* vectorMult[j];

vectorOut[j] += au[k] \* vectorMult[i];

}

}

}

void SLAE::TransposedMatrixVectorMultiplication(double\* vectorMult, double\* vectorOut)

{

for (int i = 0; i < n; i++)

{

vectorOut[i] = di[i] \* vectorMult[i];

for (int k = ia[i]; k < ia[i + 1]; k++)

{

int j = ja[k];

vectorOut[i] += au[k] \* vectorMult[j];

vectorOut[j] += al[k] \* vectorMult[i];

}

}

}

//\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* ������������ ������� \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

void SLAE::MethodOfConjugateGradientsForSymMatrix()

{

VectorCopy(x0, x);

CalculateFsubAx(x0, tmp1);

VectorCopy(tmp1, r);

VectorCopy(r, z);

double normB = VectorNorm(b);

double ak = 0, bk = 0;

double r\_rPrev = VectorScalarProduction(r); // ( r(k-1) , r(k-1) )

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

MatrixVectorMultiplication(z, tmp1); // A\*z(k-1)

double Az\_zPrev = VectorScalarProduction(tmp1, z); //( A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Az\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*A\*z(k-1)

}

double r\_rCur = VectorScalarProduction(r); // ( rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\* z(k-1)

z[i] = r[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

}

void SLAE::MethodOfConjugateGradientsForSymMatrixWithDiagP()

{

VectorCopy(x0, x);

CalculateFsubAx(x0, tmp1);

VectorCopy(tmp1, r);

VectorConditionalityForSymMatrixDiagP(tmp1, z);

VectorConditionalityForSymMatrixDiagP(r, tmp1);

double r\_rPrev = VectorScalarProduction(tmp1, r); //( M^(-1)\*r(k-1) , r(k-1) )

double normB = VectorNorm(b);

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

double ak = 0, bk = 0;

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

//VectorConditionalityForSymMatrixDiagP(r, tmp1);

//double r\_rPrev = VectorScalarProduction(tmp1, r); //( M^(-1)\*r(k-1) , r(k-1) )

MatrixVectorMultiplication(z, tmp1); //A\*z(k-1)

double Az\_zPrev = VectorScalarProduction(tmp1, z); // ( A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Az\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*A\*z(k-1)

}

VectorConditionalityForSymMatrixDiagP(r, tmp1); // M^(-1)\*rk

double r\_rCur = VectorScalarProduction(tmp1, r); //( M^(-1)\*rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\* z(k-1)

z[i] = tmp1[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

}

void SLAE::MethodOfConjugateGradientsForSymMatrixWithLuP()

{

VectorCopy(x0, x);

CalculateFsubAx(x0, r);

// M = LU

// M^(-1) = U^(-1)\*L^(-1)

SolveForwardLU(alLU, diLU, r, tmp1);

SolveBackwardLU(auLU, tmp1, z);

double normB = VectorNorm(b);

double ak = 0, bk = 0;

//ak

SolveForwardLU(alLU, diLU, r, tmp1);

SolveBackwardLU(auLU, tmp1, tmp1);

double Mr\_rPrev = VectorScalarProduction(tmp1, r); // ( M^(-1)\*r(k-1) , r(k-1) )

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

MatrixVectorMultiplication(z, tmp1); // A\*z(k-1)

double Az\_zPrev = VectorScalarProduction(tmp1, z); //( A\*z(k-1) , z(k-1) )

ak = Mr\_rPrev / Az\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*A\*z(k-1)

}

SolveForwardLU(alLU, diLU, r, tmp1);

SolveBackwardLU(auLU, tmp1, tmp1);

double Mr\_rCur = VectorScalarProduction(tmp1, r); // ( rk , rk )

bk = Mr\_rCur / Mr\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\* z(k-1)

z[i] = tmp1[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

Mr\_rPrev = Mr\_rCur;

printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

}

//\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

void SLAE::MethodOfConjugateGradientsForNonSymMatrix()

{

VectorCopy(x0, x);

CalculateFsubAx(x0, tmp1);

TransposedMatrixVectorMultiplication(tmp1, r);

VectorCopy(r, z);

double normB = VectorNorm(b);

double ak = 0, bk = 0;

double r\_rPrev = VectorScalarProduction(r); // ( r(k-1) , r(k-1) )

double r\_rCur, Az\_zPrev;

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

MatrixVectorMultiplication(z, x0); // A\*z(k-1)

TransposedMatrixVectorMultiplication(x0, tmp1);

Az\_zPrev = VectorScalarProduction(tmp1, z); //( A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Az\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*A\*z(k-1)

}

r\_rCur = VectorScalarProduction(r); // ( rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = rk + bk\* z(k-1)

z[i] = r[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

//printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

//printf("%.15lf\n", CalculateRelativeDiscrepancy(normB));

}

void SLAE::MethodOfConjugateGradientsForNonSymMatrixWithDiagP()

{

VectorCopy(x0, x);

CalculateFsubAx(x0, tmp1);

VectorConditionalityForNonSymMatrixDiagP(tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

VectorCopy(x0, r);

VectorCopy(x0, z);

double normB = VectorNorm(b);

double ak = 0, bk = 0;

double r\_rPrev = VectorScalarProduction(r); // ( r(k-1) , r(k-1) )

double r\_rCur, Az\_zPrev;

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

MatrixVectorMultiplication(z, x0); // A\*z(k-1)

VectorConditionalityForNonSymMatrixDiagP(x0, x0);

TransposedMatrixVectorMultiplication(x0, tmp1); // A^T\*A\*z(k - 1)

Az\_zPrev = VectorScalarProduction(tmp1, z); // ( A^T\*A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Az\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*A\*z(k-1)

}

r\_rCur = VectorScalarProduction(r); // ( rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\* z(k-1)

z[i] = r[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

//printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

//printf("%.15lf\n", CalculateRelativeDiscrepancy(normB));

}

void SLAE::MethodOfConjugateGradientsForNonSymMatrixWithLuP()

{

MatrixUVectorMultiplicationLU(auLU, x0, x);

CalculateFsubAx(x0, tmp1);

SolveForwardLU(alLU, diLU, tmp1, tmp1);

SolveBackwardLU(alLU, diLU, tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(auLU, x0, tmp1);

VectorCopy(tmp1, r);

VectorCopy(tmp1, z);

double r\_rPrev, r\_rCur, Newz\_zPrev, ak, bk;

r\_rPrev = VectorScalarProduction(r); // ( r(k-1) , r(k-1) )

double normB = VectorNorm(b);

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

VectorCopy(z, tmp1);

CalculateZ\_LU(tmp1); // U^(-T)\*A^T\*L^(-T)\*L^(-1)\*A\*U^(-1)\*z(k-1)

Newz\_zPrev = VectorScalarProduction(tmp1, z); //( A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Newz\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*U^(-T)\*A^T\*L^(-T)\*L^(-1)\*A\*U^(-1)\*z(k-1)

}

r\_rCur = VectorScalarProduction(r); // ( M^(-1)\*rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\*z(k-1)

z[i] = r[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

//printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

SolveBackwardLU(auLU, x, x);

//printf("%.15lf\n", CalculateRelativeDiscrepancy(normB));

}

void SLAE::MethodOfConjugateGradientsForNonSymMatrixWithLuAsterP()

{

MatrixUVectorMultiplicationLU(auLU, x0, x);

CalculateFsubAx(x0, tmp1);

SolveForwardLU(alLU, tmp1, tmp1);

SolveBackwardLU(alLU, tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(auLU, diLU, x0, tmp1);

VectorCopy(tmp1, r);

VectorCopy(tmp1, z);

double r\_rPrev, r\_rCur, Newz\_zPrev, ak, bk;

r\_rPrev = VectorScalarProduction(r); // ( r(k-1) , r(k-1) )

double normB = VectorNorm(b);

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

VectorCopy(z, tmp1);

CalculateZ\_LUaster(tmp1); // U^(-T)\*A^T\*L^(-T)\*L^(-1)\*A\*U^(-1)\*z(k-1)

Newz\_zPrev = VectorScalarProduction(tmp1, z); //( A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Newz\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*U^(-T)\*A^T\*L^(-T)\*L^(-1)\*A\*U^(-1)\*z(k-1)

}

r\_rCur = VectorScalarProduction(r); // ( M^(-1)\*rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\*z(k-1)

z[i] = r[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

//printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

SolveBackwardLU(auLU, diLU, x, x);

//printf("%.15lf\n", CalculateRelativeDiscrepancy(normB));

}

void SLAE::MethodOfConjugateGradientsForNonSymMatrixWithLuSqP()

{

MatrixUVectorMultiplicationLU(auLU, x0, x);

CalculateFsubAx(x0, tmp1);

SolveForwardLU(alLU, diLU, tmp1, tmp1);

SolveBackwardLU(alLU, diLU, tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(auLU, diLU, x0, tmp1);

VectorCopy(tmp1, r);

VectorCopy(tmp1, z);

double r\_rPrev, r\_rCur, Newz\_zPrev, ak, bk;

r\_rPrev = VectorScalarProduction(r); // ( r(k-1) , r(k-1) )

double normB = VectorNorm(b);

double RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

for (int curIt = 0; curIt < maxiter and RelDiscrepancy > eps; curIt++)

{

VectorCopy(z, tmp1);

CalculateZ\_LUsq(tmp1); // U^(-T)\*A^T\*L^(-T)\*L^(-1)\*A\*U^(-1)\*z(k-1)

Newz\_zPrev = VectorScalarProduction(tmp1, z); //( A\*z(k-1) , z(k-1) )

ak = r\_rPrev / Newz\_zPrev;

for (int i = 0; i < n; i++)

{

x[i] = x[i] + ak \* z[i]; // xk = x(k-1) + ak\*z(k-1)

r[i] = r[i] - ak \* tmp1[i]; // rk = r(k-1) - ak\*U^(-T)\*A^T\*L^(-T)\*L^(-1)\*A\*U^(-1)\*z(k-1)

}

r\_rCur = VectorScalarProduction(r); // ( M^(-1)\*rk , rk )

bk = r\_rCur / r\_rPrev;

for (int i = 0; i < n; i++) // zk = M^(-1)\*rk + bk\*z(k-1)

z[i] = r[i] + bk \* z[i];

RelDiscrepancy = CalculateRelativeDiscrepancyWithR(normB);

r\_rPrev = r\_rCur;

//printf("Iteration: %d, RelDiscrepancy of r: %.15lf\n", curIt + 1, RelDiscrepancy);

}

SolveBackwardLU(auLU, diLU, x, x);

//printf("%.15lf\n", CalculateRelativeDiscrepancy(normB));

}

void SLAE::CalculateLU()

{

for (int i = 0; i < n; i++) //i = 7

{

int i0 = ia[i]; //15

int i1 = ia[i + 1]; //19

double sumD = 0;

for (int k = i0; k < i1; k++)

{

double sumL = 0, sumU = 0;

int j = ja[k];

int j0 = ia[j];

int j1 = ia[j + 1];

int ik = i0;

int kj = j0;

for (; ik < i1 or kj < j0; )

{

if (ja[ik] < ja[kj])

ik++;

if (ja[ik] > ja[kj])

kj++;

if (ja[ik] == ja[kj]) {

sumL += alLU[ik] \* auLU[kj];

sumU += alLU[kj] \* auLU[ik];

ik++; kj++;

}

}

alLU[k] = al[k] - sumL;

auLU[k] = (au[k] - sumU) / diLU[j];

sumD += alLU[k] \* auLU[k];

}

diLU[i] = di[i] - sumD;

}

}

void SLAE::CalculateLUaster()

{

for (int i = 0; i < n; i++) //i = 7

{

int i0 = ia[i]; //15

int i1 = ia[i + 1]; //19

double sumD = 0;

for (int k = i0; k < i1; k++)

{

double sumL = 0, sumU = 0;

int j = ja[k];

int j0 = ia[j];

int j1 = ia[j + 1];

int ik = i0;

int kj = j0;

for (; ik < i1 or kj < j0; )

{

if (ja[ik] < ja[kj])

ik++;

if (ja[ik] > ja[kj])

kj++;

if (ja[ik] == ja[kj]) {

sumL += alLU[ik] \* auLU[kj];

sumU += alLU[kj] \* auLU[ik];

ik++; kj++;

}

}

alLU[k] = (al[k] - sumL) / diLU[j];

auLU[k] = (au[k] - sumU);

sumD += alLU[k] \* auLU[k];

}

diLU[i] = di[i] - sumD;

}

}

void SLAE::CalculateLUsq()

{

for (int i = 0; i < n; i++) //i = 7

{

int i0 = ia[i]; //15

int i1 = ia[i + 1]; //19

double sumD = 0;

for (int k = i0; k < i1; k++)

{

double sumL = 0, sumU = 0;

int j = ja[k];

int j0 = ia[j];

int j1 = ia[j + 1];

int ik = i0;

int kj = j0;

for (; ik < i1 or kj < j0; )

{

if (ja[ik] < ja[kj])

ik++;

if (ja[ik] > ja[kj])

kj++;

if (ja[ik] == ja[kj]) {

sumL += alLU[ik] \* auLU[kj];

sumU += alLU[kj] \* auLU[ik];

ik++; kj++;

}

}

alLU[k] = (al[k] - sumL) / diLU[j];

auLU[k] = (au[k] - sumU) / diLU[j];

sumD += alLU[k] \* auLU[k];

}

diLU[i] = sqrt(di[i] - sumD);

}

}

//\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

void SLAE::GenerateHilbertMatrix(int size)

{

n = size - 1;

for (int i = 0; i < size; i++)

{

nProfile += i;

}

ia = new int[n + 1];

AllocateMemory();

ia[0] = 0;

for (int i = 1, k = 0; i <= n; i++)

{

ia[i] = ia[i - 1] + (i - 1);

di[i - 1] = (double)1 / (2 \* i - 1);

for (int j = 1; j < i; j++, k++)

{

al[k] = (double)1 / (i + j - 1);

au[k] = (double)1 / (i + j - 1);

ja[k] = j - 1;

}

}

for (int i = 0; i < n; i++)

{

double sum = 0;

for (int xk = 1; xk <= n; xk++)

{

sum += (double)1 / (i + xk) \* xk;

}

b[i] = sum;

}

}

//\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

void SLAE::CalculateFsubAx(double \* vectorMult, double \* vectorOut)

{

for (int i = 0; i < n; i++)

{

vectorOut[i] = di[i] \* vectorMult[i];

vectorOut[i] = b[i] - vectorOut[i];

for (int k = ia[i]; k < ia[i + 1]; k++)

{

int j = ja[k];

vectorOut[i] += al[k] \* vectorMult[j];

vectorOut[j] += au[k] \* vectorMult[i];

}

}

}

void SLAE::VectorConditionalityForSymMatrixDiagP(double\* vectorIn, double\* vectorOut)

{

for (int i = 0; i < n; i++)

{

vectorOut[i] = vectorIn[i] / di[i];

}

}

void SLAE::VectorConditionalityForNonSymMatrixDiagP(double\* vectorIn, double\* vectorOut)

{

for (int i = 0; i < n; i++)

{

vectorOut[i] = vectorIn[i] / sqrt(di[i]);

}

}

void SLAE::VectorSubtract(double\* first, double\* second, double\* result)

{

for (int i = 0; i < n; i++)

{

result[i] = first[i] - second[i];

}

}

void SLAE::VectorCopy(double\* from, double\* to)

{

for (int i = 0; i < n; i++)

{

to[i] = from[i];

}

}

double SLAE::VectorScalarProduction(double\* vector1, double\* vector2)

{

double prod = 0;

for (int i = 0; i < n; i++)

{

prod += vector1[i] \* vector2[i];

}

return prod;

}

double SLAE::VectorScalarProduction(double\* vector)

{

double prod = 0;

for (int i = 0; i < n; i++)

{

prod += vector[i] \* vector[i];

}

return prod;

}

double SLAE::VectorNorm(double\* vector)

{

double norm = 0;

for (int i = 0; i < n; i++)

{

norm += vector[i] \* vector[i];

}

return sqrt(norm);

}

void SLAE::VectorOutputSolution(FILE\* out)

{

for (int i = 0; i < n; i++)

{

fprintf(out, "%.15lf\n", x[i]);

}

printf("\n");

ClearMemory();

}

void SLAE::SolveForward(double\* lowerTringMat, double\* diag, double\* rightVector, double\* vectorX) {

for (int i0, i1, i = 0; i < n; i++)

{

double sum = 0;

i0 = ia[i];

i1 = ia[i + 1];

//int j = i - (i1 - i0);

for (int k = i0; k < i1; k++)

{

int j = ja[k];

sum += lowerTringMat[k] \* vectorX[j];

}

vectorX[i] = (rightVector[i] - sum) / diag[i];

}

}

void SLAE::SolveForwardLU(double\* lowerTringMat,double \*diag, double\* rightVector, double\* vectorX) {

for (int i0, i1, i = 0; i < n; i++)

{

double sum = 0;

i0 = ia[i];

i1 = ia[i + 1];

//int j = i - (i1 - i0);

for (int k = i0; k < i1; k++)

{

int j = ja[k];

sum += lowerTringMat[k] \* vectorX[j];

}

vectorX[i] = (rightVector[i] - sum) / diag[i];

}

}

void SLAE::SolveForwardLU(double\* lowerTringMat, double\* rightVector, double\* vectorX) {

for (int i0, i1, i = 0; i < n; i++)

{

double sum = 0;

i0 = ia[i];

i1 = ia[i + 1];

//int j = i - (i1 - i0);

for (int k = i0; k < i1; k++)

{

int j = ja[k];

sum += lowerTringMat[k] \* vectorX[j];

}

vectorX[i] = (rightVector[i] - sum);

}

}

void SLAE::SolveBackward(double\* upperTringMat, double\* diag, double\* rightVector, double\* vectorX)

{

for (int i0, i1, i = n - 1; i >= 0; i--)

{

i0 = ia[i];

i1 = ia[i + 1];

vectorX[i] = rightVector[i] / diag[i];

for (int j, k = i0; k < i1; k++)

{

j = ja[k];

rightVector[j] -= upperTringMat[k] \* vectorX[i];

}

}

}

void SLAE::SolveBackwardLU(double\* upperTringMat, double\* diag, double\* rightVector, double\* vectorX) {

for (int i0, i1, i = n - 1; i >= 0; i--)

{

i0 = ia[i];

i1 = ia[i + 1];

vectorX[i] = rightVector[i] / diag[i];

for (int j, k = i0; k < i1; k++)

{

j = ja[k];

rightVector[j] -= upperTringMat[k] \* vectorX[i];

}

}

}

void SLAE::SolveBackwardLU(double\* upperTringMat, double\* rightVector, double\* vectorX) {

for (int i0, i1, i = n - 1; i >= 0; i--)

{

i0 = ia[i];

i1 = ia[i + 1];

vectorX[i] = rightVector[i];

for (int j, k = i0; k < i1; k++)

{

j = ja[k];

rightVector[j] -= upperTringMat[k] \* vectorX[i];

}

}

}

void SLAE::MatrixUVectorMultiplicationLU(double\* upperTringMat, double\* vectorMult, double\* vectorOut)

{

for (int i = 0; i < n; i++)

{

vectorOut[i] = vectorMult[i];

for (int j, k = ia[i]; k < ia[i + 1]; k++)

{

j = ja[k];

vectorOut[j] += upperTringMat[k] \* vectorMult[i];

}

}

}

void SLAE::CalculateZ\_LU(double\* vectorOut)

{

SolveBackwardLU(auLU, tmp1, tmp1);

MatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(alLU, diLU, x0, tmp1);

SolveBackwardLU(alLU, diLU, tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(auLU, x0, vectorOut);

}

void SLAE::CalculateZ\_LUaster(double\* vectorOut)

{

SolveBackwardLU(auLU, diLU, tmp1, tmp1);

MatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(alLU, x0, tmp1);

SolveBackwardLU(alLU, tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(auLU, diLU, x0, vectorOut);

}

void SLAE::CalculateZ\_LUsq(double\* vectorOut)

{

SolveBackwardLU(auLU, diLU, tmp1, tmp1);

MatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(alLU, diLU, x0, tmp1);

SolveBackwardLU(alLU, diLU, tmp1, tmp1);

TransposedMatrixVectorMultiplication(tmp1, x0);

SolveForwardLU(auLU, diLU, x0, vectorOut);

}

double SLAE::CalculateRelativeDiscrepancyWithR(double norm)

{

return VectorNorm(r) / norm;

}

double SLAE::CalculateRelativeDiscrepancy(double norm)

{

MatrixVectorMultiplication(x, tmp1);

VectorSubtract(b, tmp1, tmp1);

return VectorNorm(tmp1) / norm;

}

void SLAE::AllocateMemory()

{

al = new double[nProfile]();

au = new double[nProfile]();

di = new double[n]();

ja = new int[nProfile]();

b = new double[n]();

x = new double[n]();

x0 = new double[n]();

r = new double[n]();

z = new double[n]();

tmp1 = new double[n]();

xtrue = new double[n]();

alLU = new double[nProfile]();

auLU = new double[nProfile]();

diLU = new double[n]();

}

void SLAE::ClearMemory()

{

delete[] al;

delete[] au;

delete[] di;

delete[] ja;

delete[] b;

delete[] x;

delete[] x0;

delete[] z;

delete[] tmp1;

}

PZ3.cpp

#include <iostream>

#include <chrono>

#include "slae.h"

using namespace std::chrono;

using namespace std;

//Не забыть вынести сделать функцию для подсчета относитльной невязки (F-Ax)

int main()

{

setlocale(LC\_ALL, "Russian");

int size;

SLAE slae;

FILE\* paramf, \* iaf, \* jaf, \* alf, \* auf, \* dif, \* bf;

FILE\* out;

fopen\_s(&out, "out.txt", "w");

double seconds;

int menu;

auto start\_time = steady\_clock::now();

auto end\_time = steady\_clock::now();

printf("Введите пункт меню:\n");

printf("1) МСГ для симметричной матрицы без обуславливания\n");

printf("2) МСГ для симметричной матрицы с диагональным обуславливанием\n");

printf("3) МСГ для симметричной матрицы с LU обуславливанием\n\n");

printf("4) МСГ для несимметричной матрицы без обуславливания \n");

printf("5) МСГ для несимметричной матрицы с диагональным обуславливанием \n");

printf("6) МСГ для несимметричной матрицы с LU обуславливанием \n");

printf("7) МСГ для несимметричной матрицы с LU\* обуславливанием \n");

printf("8) МСГ для несимметричной матрицы с LU(sq) обуславливанием \n");

scanf\_s("%d", &menu);

switch (menu)

{

case 1:

fopen\_s(&paramf, "param8.txt", "r");

fopen\_s(&iaf, "ia8.txt", "r");

fopen\_s(&jaf, "ja8.txt", "r");

fopen\_s(&alf, "al8.txt", "r");

fopen\_s(&auf, "au8.txt", "r");

fopen\_s(&dif, "di8.txt", "r");

fopen\_s(&bf, "b8.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

slae.MethodOfConjugateGradientsForSymMatrix();

slae.VectorOutputSolution(out);

break;

case 2:

fopen\_s(&paramf, "param8.txt", "r");

fopen\_s(&iaf, "ia8.txt", "r");

fopen\_s(&jaf, "ja8.txt", "r");

fopen\_s(&alf, "al8.txt", "r");

fopen\_s(&auf, "au8.txt", "r");

fopen\_s(&dif, "di8.txt", "r");

fopen\_s(&bf, "b8.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForSymMatrixWithDiagP();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

case 3:

fopen\_s(&paramf, "param8.txt", "r");

fopen\_s(&iaf, "ia8.txt", "r");

fopen\_s(&jaf, "ja8.txt", "r");

fopen\_s(&alf, "al8.txt", "r");

fopen\_s(&auf, "au8.txt", "r");

fopen\_s(&dif, "di8.txt", "r");

fopen\_s(&bf, "b8.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

slae.CalculateLU();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForSymMatrixWithLuP();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

case 4:

fopen\_s(&paramf, "param12.txt", "r");

fopen\_s(&iaf, "ia12.txt", "r");

fopen\_s(&jaf, "ja12.txt", "r");

fopen\_s(&alf, "al12+.txt", "r");

fopen\_s(&auf, "au12+.txt", "r");

fopen\_s(&dif, "di12.txt", "r");

fopen\_s(&bf, "b12+.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForNonSymMatrix();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

case 5:

fopen\_s(&paramf, "param12.txt", "r");

fopen\_s(&iaf, "ia12.txt", "r");

fopen\_s(&jaf, "ja12.txt", "r");

fopen\_s(&alf, "al12+.txt", "r");

fopen\_s(&auf, "au12+.txt", "r");

fopen\_s(&dif, "di12.txt", "r");

fopen\_s(&bf, "b12+.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForNonSymMatrixWithDiagP();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

case 6:

fopen\_s(&paramf, "param12.txt", "r");

fopen\_s(&iaf, "ia12.txt", "r");

fopen\_s(&jaf, "ja12.txt", "r");

fopen\_s(&alf, "al12+.txt", "r");

fopen\_s(&auf, "au12+.txt", "r");

fopen\_s(&dif, "di12.txt", "r");

fopen\_s(&bf, "b12+.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

slae.CalculateLU();

slae.OutputLUDense();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForNonSymMatrixWithLuP();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

case 7:

fopen\_s(&paramf, "param12.txt", "r");

fopen\_s(&iaf, "ia12.txt", "r");

fopen\_s(&jaf, "ja12.txt", "r");

fopen\_s(&alf, "al12+.txt", "r");

fopen\_s(&auf, "au12+.txt", "r");

fopen\_s(&dif, "di12.txt", "r");

fopen\_s(&bf, "b12+.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

slae.CalculateLUaster();

slae.OutputLUDense();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForNonSymMatrixWithLuAsterP();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

case 8:

fopen\_s(&paramf, "param12.txt", "r");

fopen\_s(&iaf, "ia12.txt", "r");

fopen\_s(&jaf, "ja12.txt", "r");

fopen\_s(&alf, "al12+.txt", "r");

fopen\_s(&auf, "au12+.txt", "r");

fopen\_s(&dif, "di12.txt", "r");

fopen\_s(&bf, "b12+.txt", "r");

slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

slae.OutputDense();

slae.CalculateLUsq();

slae.OutputLUDense();

start\_time = steady\_clock::now();

slae.MethodOfConjugateGradientsForNonSymMatrixWithLuSqP();

end\_time = steady\_clock::now();

cout << duration\_cast<microseconds>(end\_time - start\_time).count();

slae.VectorOutputSolution(out);

break;

default:

printf("Неправильный пункт меню!");

break;

}

//fopen\_s(&paramf, "param12.txt", "r");

//fopen\_s(&iaf, "ia12.txt", "r");

//fopen\_s(&jaf, "ja12.txt", "r");

//fopen\_s(&alf, "al12.txt", "r");

//fopen\_s(&auf, "au12.txt", "r");

//fopen\_s(&dif, "di12.txt", "r");

//fopen\_s(&bf, "b12.txt", "r");

//slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

//slae.MethodOfConjugateGradientsForNonSymMatrixAtA();

//slae.MethodOfConjugateGradientsForNonSymMatrixAtAWithDiagP();

//slae.MethodOfConjugateGradientsForNonSymMatrixAtA();

//slae.VectorOutputSolution(out);

//fopen\_s(&paramf, "paramLU.txt", "r");

//fopen\_s(&iaf, "iaLU.txt", "r");

//fopen\_s(&jaf, "jaLU.txt", "r");

//fopen\_s(&alf, "alLU.txt", "r");

//fopen\_s(&auf, "auLU.txt", "r");

//fopen\_s(&dif, "diLU.txt", "r");

//fopen\_s(&bf, "bLU.txt", "r");

//slae.Input(paramf, iaf, jaf, alf, auf, dif, bf);

//slae.OutputDense();

//slae.CalculateLU();

//slae.OutputLUDense();

}