

CSE 344

System Programming

2nd Assignment

Report

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Table of Content

Algorithm.....	3
ProcessP	3
ProcessR	4
Precautions Taken & Error Handling	4
Tests	7

I have achieved all the requirements.

Algorithm

ProcessP

Process P reads the input file byte by byte and saves the read byte in a 2D char array envp. This loop continues until P reads 30 bytes. If It can't read 30 bytes(10 coordinates), loop breaks so child does not get created. After this, a child process is created with fork+execve paradigm. Coordinates are sent as environmental variables and outputpath is sent as an argument. Process P repeats this process until it reaches end of file. After reaching EOF, it checks if the children returned correctly using WIFEXITED function and if so, calcFrobeniusNorm function collects the output from output file, calculates the frobenius norms and sends them to findClosestPair function as an array.

```
wait(&status);
if(WIFEXITED(status)){
    calcFrobeniusNorm(outputPath);
}
else{
    free(buffer);
    free(childPids);
    free(frob_norms);
    free(childargv[0]);
    free(childargv);
    for(int i=0;i<10;i++){
        free(envp[i]);
    }
    free(envp);
    close(fd);
    unlink(outputPath);

    perror("a child is aborted unexpectedly");
    exit(0);
}
```

findClosestPair compares the frobenius norms and finds the two that are closest to each other and prints them to stdout using write system call.

ProcessR

Process R converts single byte environmental variables to their ASCII values and stores them as doubles (for higher precision) in a 2D array called coordinates. After this, it calculates the variance, covariance and covariance matrix of this 2D array using covMatrix function and appends the covMatrix to the end of the output file.

Precautions Taken & Error Handling

- 1) Return values of the system calls are checked and errors are handled.

```
int fd = open(inputPath, O_RDONLY, mode);

if(fd==-1){
    perror("open");
    return -1;
}
```

```
pid_t child_pid = fork();

switch(child_pid){
    case -1:
        perror ("fork");
        exit (0);
    case 0:
        execve(program,arguments,matrix);
        perror("Execve"); //execve returns only on error case.
        exit(1);
    default:
        childPids[pidsIndex++]=child_pid;
}
```

```
if(sigfillset(&mask)==-1 || sigdelset(&mask,SIGINT)==-1 || sigdelset(&mask,SIGCHLD) || sigprocmask(SIG_SETMASK, &mask, NULL)==-1){
    perror("Failed to block signals (except sigint)");
    return 1;
}
```

- 2) All signals are blocked except SIGINT and SIGCHLD to avoid interruptions and they are released after the parent process is done.

```
if(sigfillset(&mask)==-1 || sigdelset(&mask,SIGINT)==-1 || sigdelset(&mask,SIGCHLD) || sigprocmask(SIG_SETMASK, &mask, NULL)==-1){
    perror("Failed to block signals (except sigint)");
    return 1;
}
```

```
sigemptyset(&mask);
sigprocmask(SIG_SETMASK, &mask, NULL); //unblock signals
```

- 3) SIGCHLD signal has a signal handler in order to avoid zombie children. Wait system call is called every time SIGCHD is received.

```
void sigchldHandler(int signal_number){  
    sigchld_catched = 1;  
}
```

```
if(sigchld_catched==1){//to prevent zombie children  
    wait(&status);  
    sigchld_catched=0;  
}
```

- 4) Signal SIGINT has a signal handler. When ProcessP receives sigint, it forwards them to its children, frees all the resources, and removes the outputFile.

```
void sigintHandler(int signal_number){  
    sigint_catched = 1;  
}
```

```
if(sigint_catched){ //free resource  
    for(int i=0;i<pidsIndex;i++){  
        kill(SIGINT,childPids[i]);  
    }  
    free(childPids);  
    free(buffer);  
    close(fd);  
    for(int i=0;i<10;i++){  
        free(envp[i]);  
    }  
    free(envp);  
    free(frob_norms);  
    free(childargv[0]);  
    free(childargv);  
  
    unlink(outputPath);  
    exit(0);  
}
```

- 5) If outputpath already exists in the beginning of the parent process (user already has a file with the same name) it is deleted to avoid miscalculations.

```
//if the user created a file with name outputPath, remove it.  
if(access(outputPath, F_OK)) unlink(outputPath);
```

- 6) Non-determined sized arrays are created dynamically with malloc and reallocated every time they are full. So the program works regardless of file size.
- 7) Exit status of the children are checked with WIFEXITED function and if it returns false (child terminated unexpectedly), program frees all resources and exits.

```
wait(&status);  
if(WIFEXITED(status)){  
    calcFrobeniusNorm(outputPath);  
}  
else{  
    free(buffer);  
    free(childPids);  
    free(frob_norms);  
    free(childargv[0]);  
    free(childargv);  
    for(int i=0;i<10;i++){  
        free(envp[i]);  
    }  
    free(envp);  
    close(fd);  
    unlink(outputPath);  
  
    perror("a child is aborted unexpectedly");  
    exit(0);  
}
```

- 8) Child processes locks the outputFile while writing on them to avoid multiple processes writing simultaneously to same file. Used SETLKW instead of SETLK to block the other processes trying to access to file while writing.

```
lock.l_type = F_WRLCK;  
// locking file to prevent  
fcntl(fd, F_SETLKW, &lock);  
lock.l_type = F_UNLCK;  
fcntl(fd, F_SETLKW, &lock);
```

Tests

Test 1: All matrices are created successfully and there is no memory leak. (There is no reallocation in this example since input is a small text)

Input	<pre> Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.</pre>
Output	<pre>gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/sysprog_hw2\$ make gcc -o processP processP.c -lm -Wall gcc -o processR processR.c -lm -Wall gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/sysprog_hw2\$./processP -i input -o output.txt Process P reading input Created R_0 with (76,111,114),(101,109,32),(105,112,115),(117,109,32),(100,111,108),(111,114,32),(115,105,116),(32,97,109),(101,116,44),(32,99,111), Created R_1 with (110,115,101),(99,116,101),(116,117,114),(32,97,100),(105,112,105),(115,105,99),(105,110,103),(32,101,108),(105,116,44),(32,115,101), Created R_2 with (100,32,100),(111,32,101),(105,117,115),(109,111,100),(32,116,101),(109,112,111),(114,32,105),(110,99,105),(100,105,100),(117,110,116), Created R_3 with (32,117,116),(32,108,97),(98,111,114),(101,32,101),(116,32,100),(111,108,111),(114,101,32),(109,97,103),(110,97,32),(97,108,105), Created R_4 with (113,117,97),(46,10,85),(116,32,101),(110,105,109),(32,97,100),(32,109,105),(110,105,109),(32,118,101),(110,105,97),(109,44,32), Created R_5 with (113,117,105),(115,32,110),(111,115,116),(114,117,100),(32,101,120),(101,114,99),(105,116,97),(116,105,111),(110,32,117),(108,108,97), Created R_6 with (109,99,111),(32,108,97),(98,111,114),(105,115,32),(110,105,115),(105,32,117),(116,32,97),(108,105,113),(117,105,112),(32,101,120), Created R_7 with (32,101,97),(32,99,111),(109,109,111),(100,111,32),(99,111,110),(115,101,113),(117,97,116),(46,10,68),(117,105,115),(32,97,117), Created R_8 with (116,101,32),(105,114,117),(114,101,32),(100,111,108),(111,114,32),(105,110,32),(114,101,112),(114,101,104),(101,110,100),(101,114,105), Created R_9 with (116,32,105),(110,32,118),(111,108,117),(112,116,97),(116,101,32),(118,101,108),(105,116,32),(101,115,115),(101,32,99),(105,108,108), Created R_10 with (117,109,32),(100,111,108),(111,114,101),(32,101,117),(32,102,117),(103,105,97),(32,110),(117,108,108),(97,32,112),(97,114,105), Created R_11 with (97,116,117),(114,46,10),(69,120,99),(101,112,116),(101,117,114),(32,115,105),(110,116,32),(111,99,99),(97,101,99),(97,116,32), Created R_12 with (99,117,112),(105,108,97),(116,97,116),(32,110,111),(110,32,112),(114,111,105),(100,101,110),(116,44,32),(115,117,110),(116,32,105), Created R_13(110,32,99),(117,108,112),(97,32,113),(117,105,32),(111,102,102),(105,99,105),(97,32,100),(101,115,101),(114,117,110),(116,32,109), Reached EOF, collecting outputs from output.txt The closest 2 matrices are ----- 1363.290000 399.710000 63.800000 and 552.690000 -190.520000 -333.070000 399.710000 812.090000 225.700000 and -190.520000 440.760000 446.760000 63.800000 225.700000 692.800000 and -333.070000 446.760000 1498.410000 ----- and their distance is 2.980380 gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/sysprog_hw2\$</pre>
Valgrind Report	<pre>495 ==19193== HEAP SUMMARY: 496 ==19193== in use at exit: 0 bytes in 0 blocks 497 ==19193== total heap usage: 19 allocs, 19 frees, 11,735 bytes allocated 498 ==19193== 499 ==19193== All heap blocks were freed -- no leaks are possible 500 ==19193== 501 ==19193== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)</pre>

Test 2: All matrices are created successfully and there is no memory leak. (Small input like test 1)

Input	<pre>1 Facere nisi nostrum fuga repellendus illo placeat dignissimos a 2 Libero est qui voluptas repellendus consequatur qui 3 Nihil blanditiis qui neque saepe maiores praesentium id recusandae 4 Nesciunt inventore quos laborum maiores et debitis 5 Id aut laborum ratione earum animi</pre>
Output	<pre>gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/sysprog_hw2\$./processP -i input -o output.txtc Process P reading input Created R_0 with (70,97,99),(101,114,101),(32,110,105),(115,105,32),(110,111,115),(116,114,117),(109,32,102),(117,103,97),(32,114,101),(112,101,108), Created R_1 with (108,101,110),(100,117,115),(32,105,108),(108,111,32),(112,108,97),(99,101,97),(116,32,100),(105,103,110),(105,115,115),(105,109,111), Created R_2 with (115,32,97),(10,76,105),(98,101,114),(111,32,101),(115,116,32),(113,117,105),(32,118,111),(108,117,112),(116,97,115),(32,114,101), Created R_3 with (112,101,108),(108,101,110),(100,117,115),(32,99,111),(110,115,101),(113,117,97),(116,117,114),(32,113,117),(105,10,78),(105,104,105), Created R_4 with (108,32,98),(108,97,110),(100,105,116),(105,105,115),(32,113,117),(105,32,110),(101,113,117),(101,32,115),(97,101,112),(101,32,109), Created R_5 with (97,105,111),(114,101,115),(32,112,114),(97,101,115),(101,110,116),(105,117,109),(32,105,100),(32,114,101),(99,117,115),(97,110,100), Created R_6 with (97,101,10),(78,101,115),(99,105,117),(110,116,32),(105,110,118),(101,110,116),(111,114,101),(32,113,117),(111,115,32),(108,97,98), Created R_7 with (111,114,117),(109,32,109),(97,105,111),(114,101,115),(32,101,116),(32,100,101),(98,105,116),(105,115,10),(73,100,32),(97,117,116), Reached EOF, collecting outputs from output.txtc The closest 2 matrices are ----- 958.210000 -62.320000 -124.280000 and 463.760000 -289.260000 -46.220000 -62.320000 937.640000 271.860000 and -289.260000 1322.960000 123.520000 -124.280000 271.860000 120.040000 and -46.220000 123.520000 29.690000 ----- and their distance is 58.933675</pre>

Test 3: All matrices are created successfully and there is no memory leak. Input is the first two pages of the book Le Petite Prince. So, there are several reallocations. (This can be seen in the valgrind report. Test 1 and 2 has 19 allocations while Test 3 has 27).

Input	<pre>1 Once when I was six years old I saw a magnificent picture in a book, called True Stories from Nature, 2 about the primeval forest. It was a picture of a boa constrictor in the act of swallowing an animal. Here is a 3 copy of the drawing. 4 In the book it said: "Boa constrictors swallow their prey whole, without chewing it. After that they are not 5 able to move, and they sleep through the six months that they need for digestion." 6 I pondered deeply, then, over the adventures of the jungle. And after some work with a colored pencil I 7 succeeded in making my first drawing. My Drawing Number One. It looked something like this: 8 I showed my masterpiece to the grown-ups, and asked them whether the drawing frightened them. 9 But they answered: "Frighten? Why should any one be frightened by a hat?" 10 My drawing was not a picture of a hat. It was a picture of a boa constrictor digesting an elephant. But since 11 the grown-ups were not able to understand it, I made another drawing: I drew the inside of a boa 12 constrictor, so that the grown-ups could see it clearly. They always need to have things explained. My 13 Drawing Number Two looked like this: 14 The grown-ups' response, this time, was to advise me to lay aside my drawings of boa constrictors, whether 15 from the inside or the outside, and devote myself instead to geography, history, arithmetic, and grammar. 16 That is why, at the age of six, I gave up what might have been a magnificent career as a painter. I had been 17 disheartened by the failure of my Drawing Number One and my Drawing Number Two. Grown-ups never 18 understand anything by themselves, and it is tiresome for children to be always and forever explaining 19 things to them. 20 So then I chose another profession, and learned to pilot airplanes. I have flown a little over all parts of the 21 world; and it is true that geography has been very useful to me. At a glance I can distinguish China from 22 Arizona. If one gets lost in the night, such knowledge is valuable. 23 In the course of this life I have had a great many encounters with a great many people who have been 24 concerned with matters of consequence. I have lived a great deal among grown-ups. I have seen them 25 intimately, close at hand. And that hasn't much improved my opinion of them. 26 Whenever I met one of them who seemed to me at all clear-sighted, I tried the experiment of showing him 27 my Drawing Number One, which I have always kept. I would try to find out, so, if this was a person of true 28 understanding. But, whoever it was, he, or she, would always say: 29 "That is a hat." 30 Then I would never talk to that person about boa constrictors, or primeval forests, or stars. I would bring 31 myself down to his level. I would talk to him about bridge, and golf, and politics, and neckties. And the 32 grown-up would be greatly pleased to have met such a sensible man. 33 So I lived my life alone, without anyone that I could really talk to, until I had an accident with my plane in 34 the Desert of Sahara, six years ago. Something was broken in my engine. And as I had with me neither a 35 mechanic nor any passengers, I set myself to attempt the difficult repairs all alone. It was a question of life 36 or death for me: I had scarcely enough drinking water to last a week. 37 The first night, then, I went to sleep on the sand, a thousand miles from any human habitation. I was more 38 isolated than a shipwrecked sailor on a raft in the middle of the ocean. Thus you can imagine my 39 amazement, at sunrise, when I was awakened by an odd little voice. It said: 40 "If you please--draw me a sheep!" 41 "What!" 42 "Draw me a sheep!" 43 I jumped to my feet, completely thunderstruck. I blinked my eyes hard. I looked carefully all around me. 44 And I saw a most extraordinary small person, who stood there examining me with great seriousness. Here 45 you may see the best portrait that, later, I was able to make of him. But my drawing is certainly very much 46 less charming than its model.</pre>
Output	<pre>Process P reading Input Created R_0 with (79,110,99),(101,32,119),(104,101,110),(32,73,32),(119,97,115),(32,115,105),(120,32,121),(101,97,114),(115,32,111),(108,100,32), Created R_1 with (73,32,115),(97,119,32),(97,32,109),(97,103,110),(105,102,105),(99,101,110),(116,32,112),(105,99,116),(117,114,101),(32,105,110), Created R_2 with (32,97,32),(98,111,111),(107,44,32),(99,97,108),(108,101,100),(32,84,114),(117,101,32),(83,116,111),(114,105,101),(115,32,102), Created R_3 with (114,111,109),(32,78,97),(116,117,114),(101,44,10),(97,98,111),(117,116,32),(116,104,101),(32,112,114),(105,109,101),(118,97,108), Created R_4 with (32,102,111),(114,101,115),(116,46,32),(73,116,32),(119,97,115),(32,97,32),(112,105,99),(116,117,114),(101,32,111),(102,32,97), Created R_5 with (32,98,111),(97,32,99),(111,110,115),(116,114,105),(99,116,111),(114,32,105),(110,32,116),(104,101,32),(97,99,116),(32,111,102), Created R_6 with (115,119),(97,108,108),(111,119,105),(110,103,32),(97,110,32),(97,110,105),(109,97,108),(46,32,72),(101,114,101),(32,105,115), Created R_7 with (32,97,10),(99,111,112),(121,32,111),(102,32,116),(104,101,32),(100,114,97),(119,105,110),(103,46,10),(73,110,32),(116,104,101), Created R_8 with (32,98,111),(111,107,32),(105,116,32),(115,97,105),(100,58,32),(34,66,111),(100,58,32),(34,66,111),(100,58,32),(34,66,111),(100,58,32),(34,66,111), Created R_9 with (114,115,32),(115,119,97),(108,108,111),(119,32,116),(104,101,105),(114,32,112),(114,101,121),(32,119,104),(111,108,101),(44,32,119), Created R_10 with (105,116,104),(111,117,116),(32,99,104),(101,119,105),(110,103,32),(105,116,46),(32,65,102),(116,101,114),(32,116,104),(97,116,32), Created R_11 with (116,104,101),(121,32,97),(114,101,32),(110,111,116),(10,97,98),(108,101,32),(116,111,32),(109,111,118),(101,44,32),(97,110,100), Created R_12 with (32,116,104),(101,121,32),(115,108,101),(101,112,32),(116,104,114),(111,117,103),(104,32,116),(104,101,32),(115,105,120),(32,109,111), Created R_13 with (110,116,104),(115,32,116),(104,97,116),(32,116,104),(101,121,32),(110,101,),(100,32,102),(111,114,32),(100,105,103),(101,115,116), Created R_14 with (105,111,110),(46,34,10),(73,32,112),(111,110,100),(101,114,101),(108,32,100),(101,101,112),(108,121,44),(32,116,104),(101,110,44), Created R_15 with (32,111,110),(101,114,32),(116,104,101),(32,97,100),(118,101,110),(116,117,114),(101,115,32),(111,102,32),(116,104,101),(32,106,117), Created R_16 with (110,103,108),(101,46,32),(65,110,100),(32,97,),(116,101,114),(32,115,111),(109,101,32),(119,111,114),(107,32,119),(105,116,104), Created R_17 with (97,32),(99,111,108),(111,114,101),(100,32,112),(101,110,99),(105,108,32),(73,10,115),(117,99,99),(101,101,100),(101,100,32), Created R_111 with (32,115,104),(105,112,119),(114,101,99),(107,101,100),(32,115,97),(105,108,111),(114,32,111),(110,32,97),(32,114,97),(102,116,32), Created R_112 with (105,110,32),(116,104,101),(32,109,105),(100,100,108),(101,32,111),(102,32,116),(104,101,32),(111,99,101),(97,110,46),(32,84,104), Created R_113 with (117,115,32),(121,111,117),(32,99,97),(110,32,105),(109,97,103),(105,110,101),(32,109,121),(10,97,109),(97,122,101),(109,101,110), Created R_114 with (110,44,32),(97,110,32),(115,117,110),(114,105,115),(101,44,32),(119,104,101),(110,32,73),(32,119,97),(115,32,97),(119,97,107), Created R_115 with (101,110,101),(100,32,98),(121,32,97),(110,32,111),(100,100,32),(108,105,116),(116,108,101),(32,118,111),(105,99,101),(46,32,73), Created R_116 with (116,32,115),(97,105,100),(58,10,34),(102,32),(121,111,117),(32,112,108),(101,97,115),(101,45,45),(100,114,97),(119,32,109), Created R_117 with (101,32,97),(32,115,104),(101,101,112),(33,34,10),(34,87,104),(97,116,33),(34,10,34),(68,114,97),(119,32,109),(101,32,97), Created R_118 with (32,115,104),(101,101,112),(33,34,10),(73,32,100),(117,109,112),(101,100,32),(116,111,32),(109,121,32),(102,101,101),(116,44,32), Created R_119 with (99,111,109),(112,108,101),(116,101,108),(121,32,115),(101,117,110),(100,101,114),(115,116,114),(117,99,107),(46,32,73),(32,98,108), Created R_120 with (105,110,107),(101,100,32),(109,121,32),(101,121,101),(115,32,104),(97,114,100),(46,32,73),(32,108,114),(111,107,101),(100,32,99), Created R_121 with (97,114,101),(102,117,108),(108,121,32),(97,108,108),(32,97,114),(111,117,118),(108,32,109),(101,46,10),(65,110,100),(32,73,32), Created R_122 with (115,97,119),(32,97,32),(109,111,115),(116,32,101),(120,116,114),(97,111,114),(100,105,110),(97,114,121),(32,115,109),(97,108,108), Created R_123 with (32,112,101),(114,115,111),(110,44,32),(119,104,111),(32,115,116),(111,111,100),(32,116,104),(101,114,101),(32,101,120),(97,109,105), Created R_124 with (110,105,110),(103,32,109),(101,32,119),(105,116,104),(32,103,114),(101,97,116),(32,115,101),(114,105,111),(117,115,110),(101,115,115), Created R_125 with (46,32,72),(101,114,101),(10,121,),(117,32,109),(97,121,32),(115,101,101),(32,116,104),(101,32,98),(101,115,116),(32,112,111), Created R_126 with (114,116,114),(97,105,116),(32,116,104),(97,116,44),(32,108,97),(101,114),(44,32,73),(32,119,97),(115,32,97),(98,108,101), Created R_127 with (32,116,111),(32,109,97),(101,32),(111,102,32),(104,105,109),(46,32,66),(117,116,32),(109,121,32),(100,114,97),(119,105,110), Created R_128 with (103,32,105),(115,32,99),(101,114,116),(97,105,110),(108,121,32),(101,114),(121,32,109),(117,99,104),(10,108,101),(115,115,32), Reached EOF, collecting outputs from output.txtc The closest 2 matrices are ----- 1026.440000 -205.920000 -150.660000 and 1347.640000 -171.200000 -34.360000 -205.920000 779.960000 229.180000 and -171.200000 949.650000 169.500000 -150.660000 229.180000 979.640000 and -34.360000 169.500000 142.840000 ----- and their distance is 0.014364</pre>
Valgrind Report	<pre>==21124== HEAP SUMMARY: ==21124== in use at exit: 0 bytes in 0 blocks ==21124== total heap usage: 27 allocs, 27 frees, 41,943 bytes allocated ==21124== ==21124== All heap blocks were freed -- no leaks are possible ==21124== ==21124== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)</pre>

Test 4: SIGINT received

Note1: All printf's on the pictures below are used for test purposes, they don't exist in the actual code.

Note2: While testing SIGINT handlers of the parent and the children, I realized that children receive the SIGINT signal before parent sends it (as seen in the test below). I researched it and learned when parent receives SIGINT, it is propagated to children by the kernel. So, I didn't need to send the signal by myself but I send it anyways because I think using the kill function to send signals is one of the goals of this assignment.

Parent:

```
if(sigint_catched){ //clear resources and pass the signal to children
    printf("Process P received SIGINT\n");
    for(int i=0;i<pidsIndex;i++){
        kill(SIGINT,childPids[i]);
        printf("Process P forwarded SIGINT to child with PID %d\n",childPids[i]);
    }
    free(childPids);
    free(buffer);
    close(fd);
    for(int i=0;i<10;i++){
        free(envp[i]);
    }
    free(envp);
    free(frob_norms);
    free(childargv[0]);
    free(childargv);

    unlink(outputPath);
    exit(0);
}
```

Child:

```
void sigintHandler(int signal_number){
    printf("SIGINT received from child process with PID:%d\n",getpid());
    sigint_received=1;
}
```

Terminal
Output

```
^CSIGINT received from child process with PID:3609
SIGINT received from child process with PID:3585
SIGINT received from child process with PID:3613
SIGINT received from child process with PID:3597
SIGINT received from child process with PID:3593
SIGINT received from child process with PID:3601
SIGINT received from child process with PID:3605
Process P received SIGINT
SIGINT received from child process with PID:3617
Process P forwarded SIGINT to child with PID 3556
Process P forwarded SIGINT to child with PID 3581
Process P forwarded SIGINT to child with PID 3585
Process P forwarded SIGINT to child with PID 3589
Process P forwarded SIGINT to child with PID 3593
Process P forwarded SIGINT to child with PID 3597
SIGINT received from child process with PID:3556
Process P forwarded SIGINT to child with PID 3601
Process P forwarded SIGINT to child with PID 3605
Process P forwarded SIGINT to child with PID 3609
Process P forwarded SIGINT to child with PID 3613
Process P forwarded SIGINT to child with PID 3617
SIGINT received from child process with PID:3581
SIGINT received from child process with PID:3589
```

Test 5: Command Line Arguments

```
gokbey@gokbey-ABRA-A5-V15-3: ~/Desktop/1901042631/source
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP -i input -o output.txt
open: No such file or directory
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP -i input -a output.txt
Missing/Invalid command line arguments
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP -i -o output.txt
Missing/Invalid command line arguments
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP input -a output.txt
Missing/Invalid command line arguments
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP -i input -o
Missing/Invalid command line arguments
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$
```

Test 6: Not Enough Coordinates

- A) There are less than 30 bytes

```
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP -i input -o output
Process P reading input
There should be at least 2 sets (20 coordinates) in order to calculate closest 2.
```

- B) There are Less than 60 bytes

```
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$ ./processP -i input -o output
Process P reading input
Created R_0 with (68,68,68),(68,68,68),(68,68,68),(68,68,65),(68,68,68),(68,68,68),(68,68
,68),(68,68,65),(68,68,68),(68,68,68),
There should be at least 2 sets (20 coordinates) in order to calculate closest 2.
gokbey@gokbey-ABRA-A5-V15-3:~/Desktop/1901042631/source$
```