PickNik Technical Skills Evaluation

Objective

This evaluation contains a set questions designed to gauge your skills in C++, more general programming concepts, and some common robotics concepts. This is an important step for this position to ensure our expectations are aligned.

Directions

There are 9 questions total, and each of the questions is designed to have a fairly short answer. If you find yourself writing pages of code, you are doing something wrong. We've successfully compiled all the included code snippets with a modern C++ compiler. If you notice any syntax errors, please ignore them.

You may use the internet or other tools to help you answer any questions, but please do not ask others for help. As we do give this evaluation to multiple people, we ask you to please not distribute it.

Submission

It is fine if you are not able to complete every question, especially the robotics related questions, please submit whatever you are able to do.

Please provide your answers via email in a separate PDF or plain text within 2 hours of receipt of this document.

Good luck and thanks for your interest in PickNik!

1) Types

Specify the type and value for the result of each of these C++ operations:

A. `(0x16==16)`
B. `(std::list<int>().size())`
C. `(2<<3)`
D. `(2<1)`
E. `(11/4)`

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2) C++11

According to the C++11 standard, describe what happens in this program? What is the output of this program?

```
#include <iostream>

struct A {
  A() { std::cout << "A"; }
  A(const A &a) { std::cout << "B"; }
  virtual void f() { std::cout << "C"; }
};

int main() {
  A a[2];
  for (auto x : a) {
    x.f();
  }
}
```

3) Area

Please refer to the following C++ code:

```
#include <cstdio>
int* area(int length, int width)
{
  int area = length * width;
  return &area;
}

int main()
{
  printf("area = %i\n", *area(5, 6));
  return 0;
}
```

Question:

Explain, in one sentence, why there is a memory error. State the program's output, and if there is no memory error, discuss what this program is doing in memory in one sentence.

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4) Using Classes

Please refer to the following C++ code:

```
#include <cstdio>
class Foo
{
public:
  Foo() { data = new int(5); }
  ~Foo() { delete data; }
  int* data;
};

int main()
{
  Foo a;
  Foo b;
  b = a;
  *(b.data) = 20;
  printf("Data: %i\n", *(b.data) / *(a.data));
  return 0;
}
```

Question:
Explain, in one sentence, why there is a memory error. State the program's output, and if there is no memory error, discuss what this program is doing in memory in one sentence.

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5) Specialty Loggers

Please refer to the following C++ code snippet:

```
template<typename T> class Logger
{
public:
  Logger(const T& input);
  void print() const;
private:
  T data;
};
```

(Assume that we have included a generic implementation of Logger)

Part A:
Write a two line C++ snippet that instantiates a pointer to an int typed Logger class with an input of “5” and calls print().

Part B:
Suppose we want to treat `std::vector<int>` differently. Implement a template specialization of the `Logger` class for `std::vector<int>` that calls through to `Logger<int>::print()` for each element in the vector. Thus, with your implementation, the following code will result in `Logger<int>::print()` being called on the integers 5, 6, and 4.

```
std::vector<int> data;
data.push_back(5);
data.push_back(6);
data.push_back(4);
Logger<std::vector<int>> logger(data);
logger.print(data);
```

---

6) Joint Position

Please refer to the following C++ code snippet:

```
class Joint {
public:
  Joint() : position(2.0) { }
  double getPosition() const { return position; }
protected:
  double position;
};
```

Part A:
Write a class `RevoluteJoint`, that implements a method "`double squared()`" that returns the squared value of the data in `Joint`. Do so using inheritance.

Part B:
Write a class `RevoluteJoint`, that implements a method "`double squared()`" that returns the squared value of the data in `Joint`. Do so using composition.

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7) PickNik

Write a C++ application that, for each number between 1 and 100, prints `Pick` if it is divisible by 3, `Nik` if it is divisible by 5, and `PickNik` if divisible by both.

Thus, the program output should look like the following:

```
1
2
3  Pick
4
5  Nik
6  Pick
7
8
9  Pick
10  Nik
11
12  Pick
13
14
15  PickNik
16
```

(and so on...)

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8) Transformers

Explain each of the following in one or two sentences:

A) Briefly discuss a few ways to represent an arbitrary rotation and the pros and cons of each representation.
B) What is a most efficient way to calculate the inverse of a rotation matrix?
C) Describe some advantages and disadvantages of describing a robot with DH parameters vs full transforms.

9) Robotics

Explain in one or two sentences:

A) What does the Jacobian matrix of a robotic arm tell you?
B) What is a common way to perform inverse kinematics?
C) Describe some advantages and disadvantages of representing a trajectory in Cartesian space versus joint space.