Towards a New Framework For Unifying Objects Searching In LAAS

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***Abstract*—Hiding objects in various places has been of interest from a long time. Early humans wanted to hide their loots, whether they are food, treasures chest, paramour pictures or silly clues for a treasure hunt made for their colleagues.**

However, the problem of finding these hidden objects has not been tackled yet. In this work, we propose to unify the method of object finding across multiple modalities while preserving the necessary thrill and boredom inherently linked to this activity. We first describe some basic transformations and then introduce more complete ones, before concluding.

***Index Terms*—hiding objects, finding objects, best colleagues ever, quaternions**

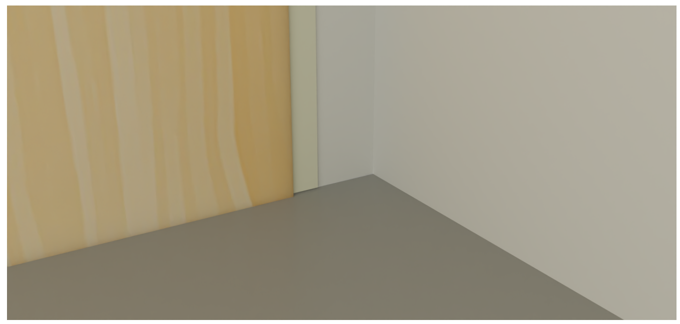

Fig. 1. The origin of the `map` frame, where everything starts.

I. Introduction

This paper assumes that the starting position is the origin of the usual `\map` frame used by HRI RIS members (Fig. 1). Any deviation would lead to incoherent locations where there is nothing hidden[1].

All the units given are in meters and radians unless specified otherwise.

Besides, the chosen notation might not be the clearest. This is an intentional choice in order not to help the reader to find the object.

II. Simple Transformations

A. Two components translation

From the initial frame of reference defined earlier, we first apply a translation function having for vector:

$$\mathbf{v} = \begin{bmatrix} 7.5 \\ 10.7 \\ 0.0 \end{bmatrix} \tag{1}$$

Please note that for simplicity purpose, in this first subsection, as in [1], we nullified the third component of $\mathbf{v}$.

B. Axis-angle rotation

We then apply a rotation around the $\mathbf{z}$ axis defined as:

$$\mathbf{z} = \begin{bmatrix} 0.0 \\ 0.0 \\ 1.0 \end{bmatrix} \tag{2}$$

We set this rotation as having an angle $\theta = 2.56$ *rad*. This rotation $\mathbf{r}$ can also be written in the so-called *axis-angle* form:

$$\mathbf{r} = \begin{bmatrix} 0.0 \\ 0.0 \\ 2.56 \end{bmatrix} \tag{3}$$

defining uniquely an axis and an angle representing any rotation in space. Indeed, the defined axis is the rotation invariant.

C. A more complex translation

We can then simply apply to this new frame, the translation defined by the vector u:

$$u = \begin{bmatrix} 2.7 & 1.9 & 1.79 \end{bmatrix}^T \tag{4}$$

III. Towards a Generic Formulation of Affine Transforms

A. Nonsense starter

To unify the expressions of both translations and rotations and ease their computation, several contributions led to the use of so-called *homogeneous matrices* [2]. By representing the start space as an hyperplane of a higher dimensional space, we are able to represent both rotations and translations[2] as affine transforms of this higher dimensional space.

By convention, the hyperplane is parallel to a plane of the higher dimensional space. For example, for a three dimensional starter space, we define a four dimensional space

[1] at least on purpose

[2] as well as scaling and shearing but they will not be used in this paper

with an orthogonal coordinate system $(A, \mathbf{x}, \mathbf{y}, \mathbf{z}, \mathbf{w})$, where our starter space is defined by the equation:

$$w - 1 = 0$$

By doing so, we can represent any transform of the starter space with affine transform on the higher dimensional space. Indeed, viewing an affine space as the complement of this hyperplane at infinity of a projective space, the affine transformations are the projective transformations of that projective space that leave the hyperplane at infinity invariant, restricted to the complement of that hyperplane. In line with the axial and null invariant of the rotation and translation respectively.

B. *(Un)formal method*

Just forget about the previous sub-section, put your rotation matrix, paste your translation vector on its right, and sprinkle a nice line of three 0s and one 1 under all this.

Then you can multiply these matrices between them to represent consecutive transformations and you can even multiply a vector to the right of the matrix to transform a point.

By the way, do so by starting from the pose found at the end of the subsection II-C and applying this homogeneous matrix M:

$$M = \begin{bmatrix} -0.4727 & 0.6627 & -0.5809 & 1.6660 \\ 0.2508 & 0.7331 & 0.6322 & -3.2043 \\ 0.8448 & 0.1532 & -0.5127 & -0.0320 \\ 0.0 & 0.0 & 0.0 & 1.0 \end{bmatrix} \quad (5)$$

(what a nice line of three 0s and one 1, we know.)

IV. (Kum)Quaternions

A. *History*

A famous mathematician, Gauss (or maybe Hilbert, or Hamilton[3], we don't remember... That is not important anyway) had children. Children back then were as annoying as today's but a lot smarter. Every morning, they asked their father not "where is the TV remote?", nor "are we there soon?", nor "do bats think we sleep upside-down?", nor "why mom left to buy cigarettes three months ago but we saw her yesterday with the physics teacher?" but "dad, have you find a way to multiply triplets?". You don't ask questions like that when you play Fortnite all day if you ask us. Anyway, annoyed by his children, this mathematician worked on week-ends and never left the lab before 9 p.m[4] and finally find a way to multiply triplets: *quaternions*.

B. *Geography*

Quaternions are actually pretty useful to represent rotations in three dimensional spaces without using matrices. You can multiply them when combining rotations and are constituted of only four real numbers ranging from -1 to 1. Please apply, to the frame of reference found at the end of the last section, the rotation corresponding to the quaterion ω:

$$\omega = \begin{bmatrix} 0.0 & -0.3851 & 0.3602 \end{bmatrix} \quad (6)$$

Reviewer1: Earlier in the paper you specify that quaternions are constituted of four numbers but Eq. 6 only presents three, I think you should refine and enrich the paper. (Also, I have a proposition for the title, can we make a meeting 2 days after the submission deadline?)

Indeed, mysterious Reviewer1, but to represent rotations in a three dimensional space, we have to add a constraint to our quaternions. Indeed, given a quaternion q:

$$q = \begin{bmatrix} x & y & z & w \end{bmatrix}$$

we must have:

$$x^2 + y^2 + z^2 + w^2 = 1$$

Put otherwise, we constrain our quaternion to leave on the four dimensional unit sphere.

V. Conclusion

In this paper we presented a new way for object hiding in several locations. We think this work can be applied in pirate treasure maps or search and rescue scenarios.

However, as going in circles leads nowhere, a final translation must be applied. From the last obtained frame, go straight in the $\mathbf{x}$ direction for about 5.62 meters. Then you should find the object of interest.

In the future we plan to never do that sort of things again, as it takes forever to find the transforms ending on the right spot and to find good puns to write the transforms in an (hopefully) entertaining way.

VI. Acknowledgment

Thanks to the english grammar to be so permissive. This paper is guaranteed without any proof reading.

References

[1] Yeh, R. W., Valsdottir, L. R., Yeh, M. W., Shen, C., Kramer, D. B., Strom, J. B., ... & Nallamothu, B. K. (2018). Parachute use to prevent death and major trauma when jumping from aircraft: randomized controlled trial. bmj, 363.

[2] Levenson, R. M., Krupinski, E. A., Navarro, V. M., & Wasserman, E. A. (2015). Pigeons (Columba livia) as trainable observers of pathology and radiology breast cancer images. PloS one, 10(11), e0141357.

[3] but before his career as a F1 pilot

[4] any resemblance to real persons living or dead is purely coincidental