Kinematic Data Streaming Over Wireless Multimedia Networks

David P. Chiasson

I. INTRODUCTION

Kinematic data is crucial to many emerging technical applications including: virtual and augmented reality, internet of things (IoT), animation, autonomous vehicles, human performance and physical therapy[1][2][3][4]. The usefulness of kinematic data, in addition to the cheap and ubiquitous existence of IMU sensors, are encouraging the usage of kinematic data in more and more applications. However, before these applications can mature, certain technologies need to be developed for efficient and standard representation and sharing of this data across information networks. Mature technologies already exist for similar multimedia types such as images, audio, and video. This paper explores the dearth of existing techniques suitable for kinematic data sharing.

Table 1: Kinematic Data (IMU values highlighted)

Position			Orientation		
x	y	z	θ	ϕ	ρ
$\dot{x}$	$\dot{y}$	$\dot{z}$	$\dot{\theta}$	$\dot{\phi}$	$\dot{\rho}$
$\ddot{x}$	$\ddot{y}$	$\ddot{z}$	$\ddot{\theta}$	$\ddot{\phi}$	$\ddot{\rho}$

II. STANDARD DATA FORMATS

A primary requirement for the sharing of information is for both parties to agree on a mutually intelligible representation. In order for a data format to be useful, it must have the following two attributes:

I. Uniquely represent all data

II. Intelligible by a second party

The first attribute is easily attained with various standard or custom data formats, including Comma Separated Value (CSV), Hierarchical Data Format (HDF) [5], and C3D[6]. These solutions are adequate if the data is for personal consumption, however, they are inadequate for data sharing. The second attribute requires this format to be known and readable by remote parties with no knowledge beyond knowledge of the format. The listed data storage formats do not include a standard way of differentiating data content. Instead, they rely on high level language processing to interpret a label such as "accel_x" to mean the magnitude of acceleration in the x direction. This shortcomming, while subtle, is restrictive if the remote party does not possess high level language processing as is the case with computers and software programs. Standard file formats must be developed which enable autonomous data processing by software systems.

Once these two basic attributes have been met, additional desired features can be considered such as lending itself to compressability and robustness in the presence of unreliable transmissions.

III. DATA COMPRESSION

The usefulness of kinematic data in any application is closely related to how much data is available and how quickly it can be received. Since modern information systems have finite limits on both storage space and transmission bandwidth, representing data in a more efficient way can improve the practicality of kinematic data for certain applications. Much work has been put into compression of other multimedia data such as audio, images and video. In those fields, dramatic compression rates such as 99% reduction have been achieved with negligible degradation[7]. The compression of kinematic data differs primarily in the lack of psychoacoustical[8] or psychovisual[9] models which can be utilized to remove "unnecessary" information, or information which is imperceptible to humans. Kinematic data compression will likely require a lossless compression algorithm as unnecessary information cannot be identified as easily. Nevertheless, the author expects, based on preliminary experiments, for kinematic data to be easily compressible on the order of 50% compared to common data-storage formats. In order to be generally beneficial, such a compression method needs to be well defined and shared.

IV. WIRELESS COMMUNICATIONS

Wireless communications is necessary if an information network contains mobile nodes which cannot be tethered to a fixed access point. While other multimedia types can be created and consumed on either a wired or wireless network, kinematic data is unique. An object possessing non-trivial kinematic data is by definition mobile, and thus wireless communications is not a convenient feature but a basic requirement.

Development of wireless communications is also necessary as the requirements of many kinematic data applications exceed that of most modern consumer applications. Consider the problem of measuring the full bio-mechanics of a person: A 9-axis IMU sensor can be placed on each of the person's fourteen main body segments[10] and sampled at 200Hz to measure normal human kinematics. This exceeds the limits for many wireless networks such as Bluetooth which limits the number of slave nodes to seven[11]. Network protocols for larger node counts exist, such as Zigbee[12], but these are designed for significantly less throughput than the 1Mbps required by our application. Wifi on the other hand performs well for bursty large amounts of data and few active nodes. However, performance degrades quickly with many active nodes due to the exponential backoff of the collision avoidance mechanism[13]. This problem is particularly pronounced when nodes send lots of small packets at regular intervals as is ideally the case with kinematic data. Kinematic applications often fall in an uncomfortable middle position, needing both many nodes and significant, predictable throughput. Kinematic applications then often have additional requirements of high synchronization and low latency. Ultra-wide band communications have been proposed as a promising solution to high performance sensor networks,[14] but investigation is still in process.

V. CONCLUSION

As the applications of information networks continue to develop, kinematic data will undoubtedly play a crucial role. However, the technology associated with processing and sharing kinematic data is severely lacking compared with other multimedia data types. This void provides an excellent opportunity for significant research contribution and progress.

References

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