Laser-Scan Mapping Software

Precision, Units and Accuracy of LSL Map Coordinates

1 *Introduction*

This note defines the method and limits of coordinate storage in IFF data files, as implemented by Laser-Scan LAMPS mapping software, and to show that no loss of coordinate precision is likely to result in ordinary use.

2 *Storage*

LSL IFF files are word-addressed direct-access binary files, with a variable length record mechanism (Entries) superimposed. Coordinates within IFF are held in ST, ZS or CB entries, depending on whether they are 2D, 3D, or multi-dimensional points. Regardless of entry type, coordinates are held as 32-bit (single precision) floating point binary numbers. This gives them a range of 10**38 to 10**-38, and between 7 and 8 significant figures.

All coordinates in a file are assumed by the software to be relative to a local origin, the value of which is held in a Map Descriptor at the start of the file, as a pair of 64-bit (double-precision) floating point binary numbers. This gives a range of 10**38 to 10**-38, and between 15 and 16 significant figures. It is not necessary that this local origin should be one of the corners or the middle of the area, merely that it should lie reasonably close to the area. Conventionally, it is often set so that the bottom left corner of the sheet lies at (0,0), but it is quite acceptable for several files to share the same origin offset, eg of the current UTM zone "brick".

3 *Units*

One of the main advantages of coordinate storage as floating point rather than integer numbers, is that IFF files are largely independent of the units of the data stored in them. Map data is often stored with ground metres as the unit, but IFF data can and does handle units as distinct as lat/long degrees, seconds of arc, feet, miles, nautical miles, sheet mm, sheet thou, or if you want to be ambitious, microns or parsecs!

The important thing to remember is that the choice of unit does not affect the precision of the data, because fractional values can be stored as easily as tens or millions.

4 *Precision*

A DEC 32-bit (single precision) floating point binary number has 1 sign bit, 8 exponent bits, and a 23 bit mantissa. Because the value is always normalised, the first mantissa bit which would always be a 1 is assumed, giving an effective mantissa of 24 bits. This gives a precision of approximately 1 part in 2**23,

allowing 33,554,433 positive values, doubled to 67,108,865 if negative values are used.

The 64-bit double precision origin offset has the same structure, but has a 55 bit mantissa, allowing more than 1,000,000,000,000,000 distinct values.

The combination of the single precision coordinate with the double precision offset allows us to store coordinates in a uniform space, which can typically cover the whole earth to a ground precision of much better than 1mm in typical sized IFF files.

The precision if you *really* want to store the whole world in one IFF file is still better than a ground metre. In large scale work where more precision is needed, the effective scale and consequent data volumes always necessitates spatial partitioning of the data, so that precision is automatically maintained.

Where multiple IFF files are handled together, as in IMERGE, or LITES2, the coordinate storage is not affected, but the *difference* in origin offsets is used to relate coordinates in the various files. The same rules about area and precision therefore apply.

5 *Accuracy*

Accuracy is a controversial subject when applied to map data. It is a term which probably best describes the "level of confidence" in a coordinate value. For typical coordinate data which has been hand digitised from printed maps, it is affected by such factors as the original surveyor's care, the geodetic calculations involving trig points, the map drawing, the printing process, the paper stretch, the digitising operator's care, the table setup method, the digitising table hardware, and the software transformation to ground units.

What is fairly certain however is that it is not affected thereafter by storage in IFF files! Because the IFF coordinates are stored in "Real World" units eg ground metres, and the same storage system is at the heart of all LSL mapping software, coordinates do not have to be transformed further in the course of normal operation, and hence do not suffer from rounding errors.

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