Telugu Measures and Arithmetic Marks

Nāgārjuna Venna

This paper is an attempt to document the historical measurement system used by the Telugu people before it was replaced by the modern metric system. The only new ground broken in this paper is a summary of new characters and signs that need to be added to the Unicode Standard for accurate encoding and rendering of Telugu books and documents.

Introduction

This paper is a summary of the historical measurement system that was used by the Telugu people before it was replaced by the modern metric system. Measures of volume, weight and length along with the arithmetic notation used to write the measures are described here. Many of the words that represent a unit of a certain measurement are still used; most often their original meaning is lost. The sections on the historical measures have been compiled from [1], [2] and [3]. The final section describes the new characters and signs that need to be added to the Unicode Standard for accurate encoding and rendering of historical books and documents.

Arithmetic Marks

The Telugus used the decimal numeral system for writing integers. Fractions were written using the quaternary numeral system (base-4). The notation is essentially a mixed system and both portions are *positional* number systems. This is not as outlandish as it sounds; the New York Stock Exchange used a similar system until February 2001 before decimalizing everything! A total of 8 basic arithmetic marks were used for writing the fractions. This is the baffling aspect of the system - why so many marks were needed when 4 would suffice for a base-4 system. Basically, two different marks were available for writing each of the quaternary digits. Based on the position, the right mark is chosen for each of the digits.

Digit	Mark Set 1	Mark Set 2
0	୧	o
1	|	—
2	Ч	⊵
3	Щ	⋛

Table 1. Telugu Arithmetic Marks

The marks in Set 1 are used for positions representing the negative odd powers of 4 (1/4, 2/4, ¾, 1/64, 2/64 etc.) and marks in Set 2 are used for positions representing the negative even powers of 4 (1/16, 2/16, 3/16, 1/256, 2/256 etc.). Zero when written from the first set is known as హళ్ళి(halli). Excluding the zero markers, the first set of markers can be understood as represented by perpendicular lines; digit 1 is represented by one

such line, 2 by two lines and 3 by three lines. Similarly, the subdivision of unity in the second set can be understood as represented by horizontal lines; digit 1 is represented by one such line, 2 by two lines and 3 by three lines. When writing a real number, the fractional part is written right after the decimal part with no intermediate signs (like a period, for example).

It was not uncommon to have the four thousand and ninety sixth part of an integer occurring in a Telugu account. Each of the basic fractions possible in a base-4 system when written in isolation (from 1/4 to 3/4096) had a given name. Each of the fractions except the first set also had an abbreviation. This abbreviation is used when writing the fraction in isolation, for example, ⏌ is 1/4, కా⏌ is 1/64 and సు⏌ is 1/1024. The names and the abbreviations are listed in Table 2.

Name	Value	Mark	Abbreviation
కాలు (kālu)	1/4	⏌	-
అర (ara)	1/2	Ч	-
ముక్కాలు (mukkālu)	3/4	Ψ	-
వీసము (vīsamu)	1/16	▬	వి
పరక (paraka)	1/8	⊇	వి
మువ్వీసము (muvvīsamu)	3/16	⋛	వి
కాని (kāni)	1/64	⏌	కా
అరవీసము (aravīsamu)	1/32	Ч	కా
ముక్కాని (mukkāni)	3/64	Ψ	కా
ప్రియ (priya)	1/256	▬	ప్రి
అరకాని (arakāni)	1/128	⊇	ప్రి
ముప్ప్రియ (muppriya)	3/256	⋛	ప్రి
సుర (sura)	1/1024	⏌	సు
రెండు సురలు (reṁḍu suralu)	1/512	Ч	సు
మూడు సురలు (mūḍu suralu)	3/1024	Ψ	సు
గోకరకాని (gōkarakāni)	1/4096	▬	గో
రెండు గోకరకానులు (reṁḍu gōkarakānulu)	1/2048	⊇	గో
మూడు గోకరకానులు (mūḍu gōkarakānulu)	3/4096	⋛	గో

Table 2. Telugu Fractions and Abbreviations

Examples

- The fraction 3/8 is written as ౦౹౽(1 * 1/4 + 2 * 1/16)

- The fraction 5/8 is written as ౦౺ ౽ (2 * 1/4 + 2 * 1/16)

- The fraction 7/8 is written as ౦౻ ౽ (3 * 1/4 + 2 * 1/16)

- The fraction 5/16 is written as ౦౹ ౼ (1 * 1/4 + 1 * 1/16)

- The fraction 7/16 is written as ౦౹౾ (1 * 1/4 + 3 * 1/16)

- The fraction 9/16 is written as ౦౺ ౼ (2 * 1/4 + 1 * 1/16)

- The fraction 11/16 is written as ౦౺ ౾ (2 * 1/4 + 3 * 1/16)

- The fraction 13/16 is written as ౦౻ ౼ (3 * 1/4 + 1 * 1/16)

- The fraction 15/16 is written as ౦౻ ౾ (3 * 1/4 + 3 * 1/16)

- The value of π (approximated to 3.14160) is written as ౩౽౽౹౦ ౼ (3 + 0 * 1/4 + 2 * 1/16 + 1 * 1/64 + 0 * 1/256 + 1 * 1/1024)

- The mathematical constant *e* (approximated to 2.718) is written as ౨౺౾౺ (2 + 2 * 1/4 + 3 * 1/16 + 2 * 1/64)

- The golden ratio φ (approximated to 1.618) is written as ౦౺ ౼౺ ౽౽౾ (1 + 2 * 1/4 + 1 * 1/16 + 3 * 1/64 + 2 * 1/256 + 0 * 1/1024 + 3 * 1/4096)

Measures

The Telugu word for measures is మానము (mānamu). This comes in three varieties - పరిమాణము (parimāṇamu), ఉన్మానము (unmānamu) and ప్రమాణము (pramāṇamu). The first is used to measure the quantities of grain and similar things (volume), the second is used to measure weights and the third in measuring extents.

It should be noted that until the eighteenth century, accurate measurements of volume were difficult and units of volume were generally named after standard containers that were defined by their capacity to hold a given weight of a particular substance (typically grains)[4]. It is not uncommon to find in use in the rural areas, even today, containers that can measure volumes like సోల (sōla), గిద్ద (gidda) and మానిక (mānika).

Measures of పరిమాణము (parimāṇamu) and ఉన్మానము (unmānamu)

In the following section, పుట్టి (puṭṭi) is described as a unit of volume and the rest of the measures are described relative to పుట్టి (puṭṭi). However, పుట్టి (puṭṭi) and the rest can also be thought of as units of weight because of the relationship described in the previous paragraph.

పుట్టి (puṭṭi)

The largest unit of volume is ఖండి (khaṁḍi) or పుట్టి (puṭṭi). In writing, this is indicated using the sign ఖ (kha). The actual bulk of a పుట్టి (puṭṭi) varies not only from place to place but also depending on the item being measured (grains, tobacco, sugar etc.). This is also the origin of the phrase పుట్టెడు విత్తనాల పట్టు నేల (puṭṭeḍu

vittanāla paṭṭu nēla), referring to the extent of land that would be sown by that quantity of grain. One twentieth of a పుట్టి (puṭṭi) is known as తూము (tūmu) and is represented by the sign ౬. In some places, it is also denoted using the letter న (na). Table 3 shows the divisions of a పుట్టి (puṭṭi).

తూము (tūmu)	౬౧
ఇద్దుము (iddumu)	౬౨
ముత్తుము (muttumu)	౬౩
నల్తుము (naltumu)	౬౪
ఏదుము (ēdumu)	ఖ౧ం
ఆర్దుము (ārdumu)	ఖ౧౧
ఏడ్డుము (ēḍdumu)	ఖ౧౨
ఎనమందుము (enamaṁdumu)	ఖ౧౩
తొమ్మందుము (tommaṁdumu)	ఖ౧౪
పందుము (paṁdumu)	ఖ౦౪ం
పదకొల్తుము (padakoltumu)	ఖ౦౪౧
పన్నిద్దుము (panniddumu)	ఖ౦౪౨
పదముత్తుము (padamuttumu)	ఖ౦౪౩
పధ్నల్తుము (padhnaltumu)	ఖ౦౪౪
పదిహేదుము (padihēdumu)	ఖ౦౪ం
పదహార్దుము (padahārdumu)	ఖ౦౪౧
పదిహేడ్డుము (padihēḍdumu)	ఖ౦౪౨
పధెనమందుము (padhenamaṁdumu)	ఖ౦౪౩
పందొమ్మందుము (paṁdhommaṁdumu)	ఖ౦౪౪
పుట్టి (puṭṭi)	ఖ౧

Table 3. Divisions of పుట్టి (puṭṭi)

Each తూము (tūmu) is divided into four కుంచములు (kuṁcamulu) that are marked as shown in Table 4.

కుంచము (kuṁcamu)	౬౹
ఇరస (irasa)	౬౺

ముక్కుస (mukkusa)	౭౫
తూము (tūmu)	౭౦

Table 4. Divisions of తూము (tūmu)

Each కుంచము (kuṁcamu) is divided into four మానికలు (mānikalu) that are marked as shown in Table 5.

మానిక (mānika)	మా౦
అడ్డ (aḍḍa)	మా౨
మూడు మానికలు (mūḍu mānikalu)	మా3
కుంచము (kuṁcamu)	౭౹

Table 5. Divisions of కుంచము (kuṁcamu)

Each మానిక (mānika) is divided into four సోలలు (sōlalu) that are marked as shown in Table 6.

సోల (sōla)	సో౦
తవ్వ (tavva)	సో౨
మూడు సోలలు (mūḍu sōlalu)	సో3
మానిక (mānika)	మా౦

Table 6. Divisions of మానిక (mānika)

Each సోల (sōla) is divided into four గిద్దలు (giddalu) that are marked as shown in Table 7.

గిద్ద (gidda)	గి౦
అర సోల (ara sōla)	గి౨
మూడు గిద్దలు (mūḍu giddalu)	గి3
సోల (sōla)	సో౦

Table 7. Divisions of సోల (sōla)

బారువ (bāruva)

The largest Telugu weight is a బారువ (bāruva). One twentieth of a బారువ (bāruva) is known as మణుగు (maṇugu) and denoted by మ (ma). Each మణుగు (maṇugu) has eight వీశెలు (vīśelu) denoted by the letter వీ (vī) and each వీశె (vīśe) has five శేర్లు (śērlu) denoted by the letter శే (śē). Some of the divisions of మణుగు (maṇugu) are shown in Table 8.

ఎత్తు (ettu) (adj. ఎత్తెడు (etteḍu))	మ ౧౦
అర్ధ మణుగు (ardha maṇugu)	మ ౦౪౦
మూడెత్తులు (mūḍettulu)	మ ౦౪౦
వీశె (vīśe) (adj. వీశెడు (vīśeḍu))	వీ ౧ or శే ✕
అరవీశె (ara vīśe)	శే ౨౪౦
సవాశేరు (savāśēru) or శేరుంపావు (śēruṁpāvu)	శే ౧౦
అర్ధశేరు నవటాకు (ardhaśērunavaṭāku)	శే ౦౪ ౽
అర్ధశేరు (ardha śēru)	శే ౦౪౦
పావుశేరు (pāvuśēru)	శే ౧౦
నవటాకు (navaṭāku)	శే ౦౪౽
చటాకు (caṭāku)	శే ౦౪−

Table 8. Divisions of మణుగు (maṇugu)

Miscellaneous measures

8 మణుగులు (maṇugulu) make one సాగరము (sāgaramu). Each నవటాకు (navaṭāku) is equivalent to three తులాలు (tulālu). The తులము (tulamu) is the weight of one rupee coin (one hundred and eighty grains) and is used in weighing medicines.

Measures of ప్రమాణము (pramāṇamu)

The greatest measurement of length is a యోజనము (yōjanamu), sometimes also called ఆమడ (āmaḍa). (Under the British government, the ఆమడ (āmaḍa) was about 10 miles). Each యోజనము (yōjanamu) has four పరుగులు (parugulu) or కోసులు (kōsulu). The పరుగు (parugu) or కోసు (kōsu) is a variable measure running between two and two and a half miles. Each పరుగు (parugu) or కోసు (kōsu) is equivalent to 1000 దండములు (daṁḍamulu). Each దండము (daṁḍamu) has two బారలు (bāralu) or *fathoms*. Each బార (bāra) has two గజములు (gajamulu) or *yards*. Each గజము (gajamu) has two మూరలు (mūralu) or *cubits*. Each గజము (gajamu) also has three అడుగులు (aḍugulu) or *feet*. Each అడుగు (aḍugu) has twelve అంగుళములు (aṁguḻamulu) or *inches*. Each మూర (mūra) is made of two జేనలు (jēnalu) or *spans*. Each జేన (jēna) has three బెత్తెలు (bettelu). The English acre is spelled as యకరాలు (yakarālu).

The కుంట (kuṁṭa) or గుంట (guṁṭa) is the basic unit of measurement when dealing with square measures of

land. The గుంట (guṁṭa), which literally means a hole or a well, is that amount of land that can be irrigated by one well. This measure varies from place to place; in Bombay 40 కుంటలు (kuṁṭalu) made one acre. There are two varieties of కుంటలు (kuṁṭalu); పెద్ద కుంటలు (pedda kuṁṭalu) and చిన్న కుంటలు (cinna kuṁṭalu). One గొఱ్ఱు (gorṟu) is made of 50 పెద్ద కుంటలు (pedda kuṁṭalu) or 125 చిన్న కుంటలు (cinna kuṁṭalu). 64 కుంటలు (kuṁṭalu) make one కుచ్చెల (kuccela).

Unicode

The Unicode Standard is the universal character-encoding scheme for written characters and text. It defines a consistent way of encoding multilingual text that enables the exchange of text data internationally and creates the foundation for global software. It provides the capacity to encode all characters used for the written languages of the world. The Unicode Standard specifies a numeric value (code point) and a name for each of its characters. Telugu is encoded in the Basic Multilingual plane (BMP) of the standard; this represents the first 65,536 code points which is used to encode the majority of the common characters of the major languages of the world. Telugu characters are assigned code points between U+0C00 (3072) and U+0C7F (3199). See [5], [6] for more details.

The current version of the Unicode Standard (Version 4.1) encodes most of the characters and signs used in writing modern Telugu script. However, some of the characters and signs that are necessary for accurate digitizing of many books and old documents are missing from the standard. For the material described in this paper, 8 new signs should be added to the standard. These include 6 signs shown in Table 1 (2 each for digits 1, 2 and 3), the sign for హళ్ళి (haḷḷi) and the sign for తూము (tūmu). There is no need for a separate sign for

the cypher in Mark Set 2 of Table 1 because U+0C66 (TELUGU DIGIT 0) is adequate for representing it. Table 9 lists the suggested code points and character names.

0C78		TELUGU SIGN HAḶḶI
0C79		TELUGU FRACTION $1/4^n$, for odd n
0C7A		TELUGU FRACTION $2/4^n$, for odd n
0C7B		TELUGU FRACTION $3/4^n$, for odd n
0C7C		TELUGU FRACTION $1/4^n$, for even n
0C7D		TELUGU FRACTION $2/4^n$, for even n

| 0C7E | | TELUGU FRACTION 3/4^n, for even n |
| 0C7F | | TELUGU SIGN TŪMU |

Table 9. Suggested codepoints and character names

Future Work

1. There were many other less well-known measures used; it would be worthwhile to document them.
2. A mapping from the historical measures to modern metric measures would be helpful for comparison purposes.

Acknowledgements

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