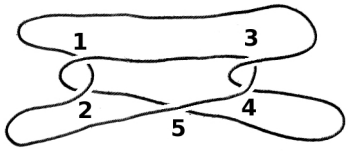
String Figure Analyser

The following examples illustrate some uses of the program.

There are two groups of string figures which this program will not unravel. In the first group are those—such as *Laughing Jackass* (*BISFA* 2: 133)—which at some stage require an increase in complexity through Reidermeister Moves 1 and 2 before the complexity can be reduced. In the second group are those—such as *Beluga* (*BISFA* 16: 64)—which require a long series of adjustments by Reidermeister Move 3 before further reductions can take place. But a great many string figures—such as those included in the samples—present no problem. For further information, see the article 'The testing and correcting of string-figure diagrams' in *BISFA* 20. (*BISFA = Bulletin of the International String Figure Association*).

Figure 1: If this design is not a string figure, can we make it one?



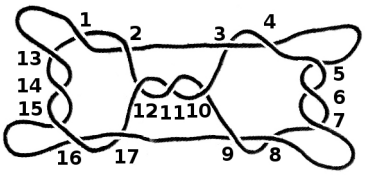
1 Starting at the top left of Fig. 1, and moving to the right, list each crossing passed, and precede it with a negative sign on each occasion that the segment being followed passes under another segment. This leads to the following sequence: **3 -4 -5 -2 1 -3 4 5 2 -1**
This is similar to Gauss Code, but K. F. Gauss (1777-1855) would have written O3+U4+U5+ etc.

2 Click **Samples** then **SFA Figure 1**, which will load the above sequence into the Input box.
3 Click **Check Input**. Any errors detected will appear in the Messages panel. If no errors are detected, the sequence will be copied into the Sequence panel.
4 Click **Analyse**. The sequence may vanish, or several terms will remain. In the present example, the Sequence panel now contains 3 -2 1 -3 2 -1. A suggestion appears in the Messages panel recommending that the weave of one or more *reversible groups* (see below) is altered. Since {**1 2**} is a reversible group, and **1** and **2** are both present in the Sequence panel, we can proceed as follows.
5 Enter **1 2** in the Weave Entry box, and click **Change weave of**. The signs of the four terms involving **1** or **2** will change in the Sequence panel.
6 Click **Analyse** once more. The Messages panel contains an announcement that an Open Loop has been produced. Thus the design in **Fig. 1**, when the weave is changed at crossings **1** and **2**, is a string figure.

Reversible Groups

The reversible groups in Fig. 1 are {1 2}, {3 4} and {5}. I call these 'reversible groups' because the weave of the crossings in any such groups can be reversed without altering either the silhouette or the stability of the design (although the change may well transform a string figure into a knot, or a knot into a string figure). It is understood, of course, that *the string figures we are discussing are displayed under tension*. Although the program will allow you to change just part of a reversible group, and see if the design unravels, it does not follow that the same change to the original string design will turn that design into a string figure. The stability of a string design is only preserved when the weave of an *entire* reversible group is modified.

Figure 2: An invented design. Is it a string figure?



1 The sequence is: 1 -2 3 -4 -5 6 -7 -8 9 -10 11 -12 2 -1 -13 14 -15 -16 17 -9 8 7 -6 5 4 -3 10 -11 12 -17 16 15 -14 13
and the reversible groups are {1 2}, {3 4}, {5 6 7}, {8 9}, {10 11 12}, {13 14 15} and {16 17}.

2 Click **Samples** then **SFA Figure 2** to load the sequence into the Input box. Click **Check Input**, click **Analyse**, and once again the sequence will be reduced, but several terms will remain. Compare the reduced sequence with Fig. 2, and note that the terms in the reversible group {10 11 12} are present in the reduced sequence.
3 Enter **10 11 12** in the Weave Entry box, and click **Change Weave of**. The signs of the terms involving **10 11 12** will change in the Sequence panel.
4 Click **Analyse** once more. The Sequence panel contains an announcement that an Open Loop has been produced. Thus the design in **Fig. 2**, when the weave is changed at crossings **10 11 12**, becomes a string figure.

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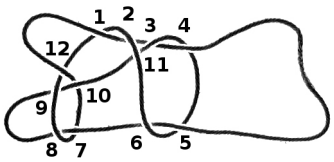
Figure 3: The Inuit *Bear* : does there exist a string figure look-alike?

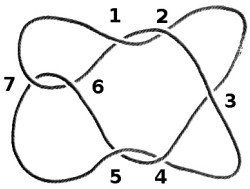


1 The sequence for the *Bear* is
1 -2 -3 4 5 -6 7 -8 -9 10 -11 3 -4 -5 6 11 2 -1 -12 9 8 -7 -10 12
and the reversible groups are
{1 2}, {3 4}, {5 6}, {7 8}, {9 10 12} and {11}.

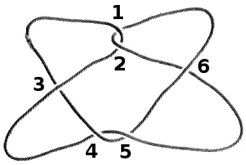
2 Click **Samples** then **SFA Figure 3** to load the sequence into the 'Input' box.
3 Now, by clicking **Check Input**, changing the **Weave** of one or more reversible groups, and clicking **Analyse**, it is revealed whether that choice of changes results in a string figure *look-alike* (that is, in a figure that has the same silhouette as the *Bear*, but differs in the weave at one or more crossings). It doesn't take long to find one. (There are, including the *Bear*, a total of 22 string figure look-alikes.) For example, one string figure look-alike is obtained by changing the weave of the crossings 3 4 5 6 — that is, those in the reversible groups {3 4} and {5 6}.

Figures created by design: If a neat construction for some figure that you have designed is elusive, the figure can be transformed by the **Analyser** into a look-alike, and a construction then found for the resultant figure. Each look-alike, and there may be many of them, will have a different construction

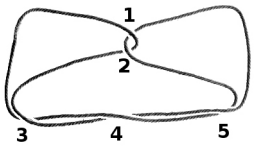
Four quickly-analysed designs: To help gain familiarity with the **Analyser**, here are a few simple designs to investigate. Each is a knot. Three can be converted into string figure look-alikes, but one will stubbornly refuse to turn into anything but a knotted look-alike. The reversible groups are given beneath each design.



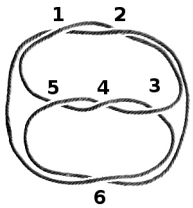
{1 2} {3} {4 5} {6 7}



{1 2} {3} {4 5} {6}



{1 2} {3 4 5}



{1 2} {3 4 5} {6}

***Bagobo Diamonds**:* In Jayne's *String Figures* (1906, Dover reprint 1962) page 49, the diagram for *Bagobo Diamonds* is incorrect. Load the sequence from the Samples, **Check Input**, **Analyse**, change the weave, and **Analyse** again. You'll need to know that {9}, {10 11} and {24 25} are some of the reversible groups.

Use of the program: When entering input, the text will wrap automatically. There's no need to include a terminal character. Note that, if any other character (including ENTER) is included, that character will terminate the sequence. After entering data into the Input box, the TAB key will transfer control to the **Check Input** button, and ENTER will activate the button. TAB will then take you to the Weave Entry box, and, after entering any data, TAB then ENTER will activate the **Change Weave** button, after which TAB then ENTER will activate the **Analyse** button. As long as the initial input remains in the Input box, you can restart work on the current design by once more clicking on **Check Input** (or by pressing ALT c).

Three dimensional figures: If a projection onto the plane is made of a three dimensional string design, 'virtual crossings' will appear in which the apparently intersecting string segments are in fact separated in space. These virtual crossings must be diagrammed and labelled along with the actual crossings, and entered in the Input panel. But virtual crossings, since the string segments are not in contact, and there is thus no weave to change, can never be part of any reversible group.

String figures composed of several loops: For string designs consisting of two or more loops, refer to the pen-and-paper method described in *BISFA* 20.

Complex figures with obscure regions: These can be tackled by stitching the sequences for those string segments that are clearly defined together with the various possibilities for the unknown segments.

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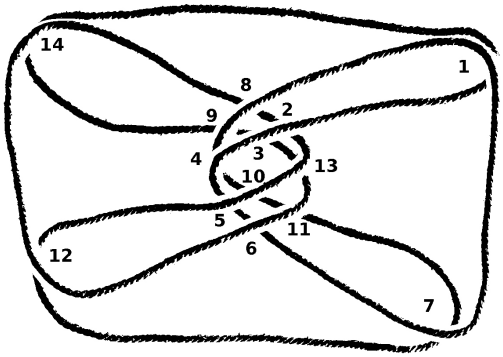
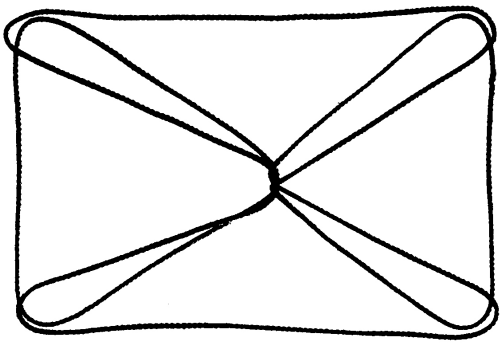
The Flag : from initial design to the construction of a new figure

First, a design is created on paper, and the crossings labelled (below left):





The sequence is entered into the **Analyser**, after which we click **Check Input** and **Analyse Sequence**.

Input

-1 2 3 4 -5 -6 7 1 8 9 -4 -10 -11 -7 -12 5 10 13 -2 -8 14 12 6 11 -13 -3 -9 -14

The **Analyser** suggests that, to obtain a string figure, the weave of one or more reversible groups must be changed. We identify the reversible groups as: {1} {7} {12} {14} {2 5} {3 6} {4} {8 10} {9 11} {13}.

You are the designer, and as such you have a choice. You might choose to preserve (in addition to the silhouette) the overall structure of the central region. In that case your reversible groups will be {1} {7} {12} {14} {2 3 4 5 6 8 9 10 11 13}. The choice is yours. Once you have made your choice, the **Analyser** will do the rest. But here, we take the reversible groups as those given in the previous paragraph.

To preserve the symmetry of the corners of the design, which might lead to an easier construction, we leave the weave unchanged at 1, 7, 12 and 14. We experiment by changing the weave of the remaining groups. The **Analyser** quickly reveals that a string figure is obtained if the weave is changed at {2 5} and {3 6}.

	Weave Entry	Weave reversed at:
Change weave of:		2 5 3 6

We now take a length of string, weave the modified design, tie the ends together and, after less than five minutes experimentation, discover the following construction:

The Flag

1. Loop around thumbs and little fingers of both hands (Position 1).
2. Right middle finger, from above, hooks up the left palmar string, and turns to oneself and up.
3. Left thumb and little fingers, from above, remove the right middle finger loop.
4. Right middle finger picks up the crossed palmar strings of the left hand.
5. Left ring finger, from above through the right middle finger loop, picks up the right palmar string.
6. Left middle finger, from above, removes the left ring finger loop.
7. Release the double loop from the right middle finger.
8. Right thumb and little fingers, from above, remove the left middle finger loop.
9. Extend to give the *Flag* (above right).

Where to find more information: If you are new to string figures and find the subject fascinating, I can recommend the *Bulletins* of the International String Figure Association. The complete set from 1994 would cost a bit, but contains a wealth of material, including construction methods for extensive string figure collections from all over the world, performance ideas, history, analytical material, correspondence, and recently-invented figures. You'll need about a foot (30cm) of shelf space for all issues up to the present.

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