The theory of morphological analysis applied to western apparel－a case study of Renaissance era

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Summary

This paper is aimed at using morphological analysis to augment seeking clothing design solutions. A case of western apparel in Renaissance era is applied to illustrate how to use this powerful fast-developing design computer tool. In using morphological analysis, we first divide western apparel into several independent design attributes, such as headdress, neckline, sleeves, farthingale, cobsters for female and ruff, doublet, zimarre, sleeves, cannions, duckbill shoes for male. Secondly, we find all possible design solutions for each design attribute. Finally, we can establish morphological matrix charts, which can be transformed as inputs for computer searches or computer-supported design decision-making and enlarge clothing design idea areas. In conclusion, morphological analysis is a potential computer tool used to aid apparel designers to obtain innovative ideas.

Key words:
morphological analysis, computer-aided design, western apparel, Renaissance era, fashion design.

1. Introduction

How to quickly search for lots of ideas is always the most important thing to designers. Brainstorming (created by Osborn in 1963, also called Osborn method) and synectics (created by Gordon in 1961, also called Gordon method) play important roles to reach this goal. But these two useful ideation tools require a particular design team, usually 5 to 8 persons or experts, to perform the creation process. In addition, these two ideation methods are very difficult to computerize their creation process. Therefore, in the past, most designers still depended on these traditional human-power methods to collect required ideas [1, 2].

Morphological analysis was first recommended by Zwicky in 1947 [3]. It is also a very useful creation tool to designers. Since this ideation method require a lot of information, time and costs before to perform the process, hence most designers refuse to use this method. There are only few large companies can afford to use it.

Due to the emergence of personal computer and the global internet services, some designers begin to acknowledge the advantages of morphological analysis. The systemic and logical performing process together with complicated information process is very suitable for applying computer and internet searching. Nowadays, some design scholars have attempted to study the computer application of morphological analysis and have obtained some achievements, such as Richardson and Pugh's work on their computerized DYNAMO model [4], Blaich"s design application to his famous best-selling products [5], Owen's computer-supported structure planning [6], Ulin, Armstrong and Radwin's computer-aided posture control [7] and Chen's computer simulation of shoe cast [8].

In the present we know morphological analysis is a powerful computer tool to aid engineering and product designers to widen design idea areas. But to apparel designers, morphological analysis is still unused as before, because of the drawbacks of time and costs. Right now, we can not find any computer theory and application of morphological analysis in the literature in the field of apparel design. Also we know that the soft clothing materials and the various human body-forms have limited the use [9, 10].

In view of this, the authors launched into the study of morphological analysis applied to western apparel. A case of western apparel in Renaissance era is experimented as an example to use this potential computer new tool.

2. The Theory of Morphological Analysis Applied to Western Apparel in Renaissance era

2.1 General theory of morphological analysis applied to western apparel

The aim of morphological analysis is to widen the area of search for solutions to a design problem. Generally, three steps are followed by using this powerful computer tool. Firstly, we define the functions that any acceptable design must be able to perform. Secondly, we list, on a chat, a wide range of sub-solutions, i.e. alternative means of performing each function. Finally, we select an acceptable set of sub-solutions, one for each function. Morphological analysis combined with computer searches is intended to efficiently force divergent thinking and to safeguard against overlooking novel solutions to a design problem.

Table 1 illustrates a general example of Morphological matrix chart, which can be transformed into the inputs of computer searches for lots of innovative design ideas.

Table 1 General example of morphological matrix chart

design attributes / optional solutions	A	B	C	D	E	F	G	H	◆◆◆◆
Option 1									
Option 2									
Option 3									
◆ ◆									

To illustrate the general theory of morphological analysis applied to western apparel, we have to know more about the relationship between human body and apparel. To apparel, human body can be regarded as integrated sets of geometric form. The head of an ordinary adult is a oval. Neck, arms and legs are mostly cylinders. The female truck is commonly a funnel or a cylinder. The parts of shoulder, waist, kneel joints, breasts and hip are mostly a doom or a sphere （Fig. 1）. The male truck is mostly a cylinder. But, if the shoulder is much wider than the waist, he will become a reverse cone shape （Fig. 2）[11, 12, 13].
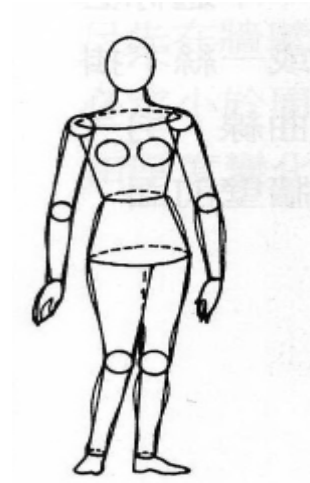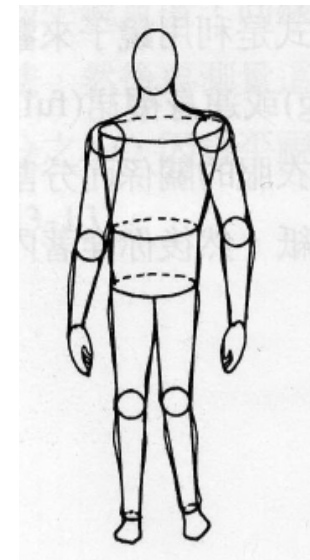

Fig. 1 Main geometric forms of female

Fig. 2 Main geometric forms of male

The western apparel is usually made according to the above-mentioned geometrical characteristics of human body. Therefore, we can decode western apparel into detail parts. In general, the upper parts of male apparel mainly include doublet, jerkin, slash, zimarre and ruff. The lower parts of male mainly include cannions, socks and lower skirt or trout （Fig. 3）. The female apparel can be decoded into headdress, hair style, neckline, sleeves and lower clothing （Fig. 4）[14, 15, 16].
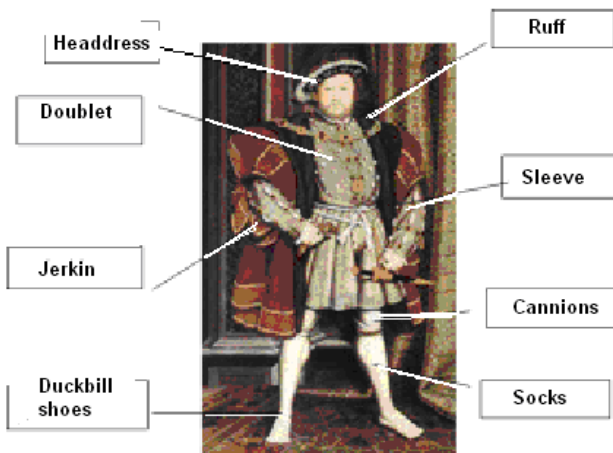
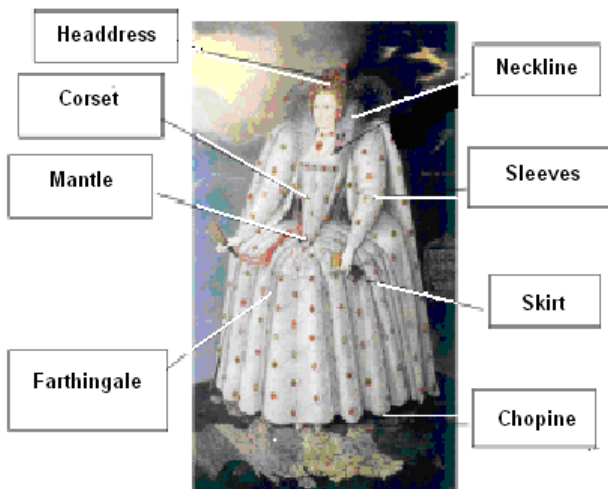Fig. 3 Typical classification of male apparel

Fig. 4 Typical classification of female apparel

Accordingly, this research first presents six steps to perform morphological analysis for western apparel design. The steps are further depicted in detail as follows.

Step No. 1

To decode western apparel into independent detail parts and put them on the horizontal axis. Items on the vertical axis are all options of each detail part. Table 2 shows an example of the finished morphological matrix chart with all design solutions in picture state.

Table 2 Morphological matrix chart for apparel（design solutions are pictures）

Attributes / Apparel styles	A. Headdress	B. Doublet	C. Jerkin	D. Neckline	E. Sleeves
Option 1					
Option 2	Picture	Picture	Picture	Picture	Picture
Option 3	Picture	Picture	Picture	Picture	Picture
Option 4	Picture	Picture	Picture	Picture	Picture
Option 5	Picture	Picture	Picture	Picture	Picture

Step No. 2

Use the same process as step No. 1, but design solutions are in profile state. Table 3 shows an example of the finished morphological matrix chart.

Table 3 Morphological matrix chart for apparel（design solutions are profiles）

Attributes / Apparel styles	A. Headdress	B. Doublet	C. Jerkin	D. Neckline	E. Sleeves
Option 1					
Option 2	Profile	Profile	Profile	Profile	Profile
Option 3	Profile	Profile	Profile	Profile	Profile
Option 4	Profile	Profile	Profile	Profile	Profile
Option 5	Profile	Profile	Profile	Profile	Profile

Step No. 3

To focus on European national apparel styles and put them on the vertical axis of morphological matrix chart, as shown in Table 4.

Table 4 Morphological matrix chart for western apparel (focusing on national styles)

Attributes / Styles	A	B	C	D	E
Italian	ture	Picture	Picture	Picture	Picture
Germany	ture	Picture	Picture	Picture	Picture
Spanish	ture	Picture	Picture	Picture	Picture
English	ture	Picture	Picture	Picture	Picture
Others	ture	Picture	Picture	Picture	Picture

Step No. 4

Use the same process as step No. 3, but design solutions are in profile state. Table 5 shows an example of the finished morphological matrix chart.

Table 5 Morphological matrix chart for western apparel (design solutions are profiles)

Attributes / Styles	A	B	C	D	E
Italian	ture	Profile	Profile	Profile	Profile
Germany	ture	Profile	Profile	Profile	Profile
Spanish	ture	Profile	Profile	Profile	Profile
English	ture	Profile	Profile	Profile	Profile
Others	ture	Profile	Profile	Profile	Profile

Step No. 5

Use the same process as step No. 4, but design solutions are the characteristics descriptions of each apparel profile. Table 6 shows an example of the finished morphological matrix chart.

Table 6 Morphological matrix chart for western apparel (design solutions are Characteristics descriptions)

Attributes / Styles	A.Headdress	B. Doublelet	C. Jerkin	D. Neckline	E. Sleeves
Italian	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description
Germany	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description
Spanish	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description
English	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description
Others	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description	Characteristics Description

Step No. 6

Use the morphological matrix charts established from Step No 1 to Step No 5 to aid apparel design or to search western apparel. This step can use computer to increase the efficiency and improve the design decision quality.

(1) Morphological matrix charts aiding apparel design

Table 7 shows one example of applying morphological matrix charts to aid apparel design. In this example, there are 7775 ($6^5-1=7775$) design decision values. X, Y and Z represent three choices from the decision maker（apparel designer）. X decision value means the designer using attribute A, option 2＋attribute B, option 5 （denoted as X=A2+B5+C0+D0+E0 ,or simply（2,5,0,0,0）） to design his work; Y decision value means the designer using attribute A, option 1＋attribute B, option 3＋attribute C, option 2 ＋ attribute D, option 5 ＋ attribute E, option 4 （denoted as Y=A1+B3+ C2+D5+E4, or simply（1,3,2,5,4）） to design his work. With the same performing procedure, Z decision value can be denoted as Z=A5+B2+C4+D3+E2, or simply（5,2,4,3,2）.

Table 7 One application example of Morphological matrix chart (X, Y and Z are design decision values)

Attributes / Apparel styles	A. Headdress	B. Doublelet	C. Jerkin	D. Neckline	E. Sleeves
Option 1	Picture	Picture	Picture	Picture	Picture
Option 2	Picture	Picture	Picture	Picture	Picture . Z
Option 3	Picture	Picture	Picture	Picture	Picture
Option 4	Picture	Picture	Picture	Picture	Picture Y
Option 5	Picture	Picture X	Picture	Picture	Picture

(2) Morphological matrix charts to aid western apparel searching

Applying the morphological matrix charts established from step No 1 to step No 5, if we input desired searching conditions, we can obtain the western apparel solution. For examples：

（Example 1）
Input conditions：The jerkin profile with Italian style
Output result（Φ）：The apparel solution as shown in Table 8.
Φ＝C1；or denoted as （0,0,1,0,0）

（Example 2）

Input conditions ： The neckline picture with
                    Germany
                    style

Output result （Ω）： The apparel solution as shown
                      in Table 9.

$$\Omega = D2 ；or\ denoted\ as\ （0,0,0,2,0）$$

Table 8 One application example of Morphological matrix chart (**Φ** is the searching result)

Attributes \ Styles	A. Headdress	B. Doublelet	C. Jerkin	D. Neckline	E. Sleeves
Italian 1	Profile	Profile	Φ	ofile	Profile
Germany 2	Profile	Profile		..ofile	Profile
Spanish 3	Profile	Profile	Profile	Profile	Profile
English 4	Profile	Profile	Profile	Profile	Profile
Others 5	Profile	Profile	Profile	Profile	Profile

Table 9 One application example of Morphological matrix chart (**Ω** is the searching result)

Attributes \ Styles	A. Headdress	B. Doublelet	C. Jerkin	D. Neckline	E. Sleeves
Italian 1	Picture	Picture	Picture	Picture	Picture
Germany 2	Picture	Picture	Picture	Ω	Picture
Spanish 3	Picture	Picture	Picture		Picture
English 4	Picture	Picture	Picture	Picture	Picture
Others 5	Picture	Picture	Picture	Picture	Picture

2.2 A case application of western apparel in Renaissance era

The various forms and styles of western apparel in Renaissance era are very complicated and suitable for using morphological analysis. Therefore, we choose it as our case study. Also, we can easily find lots of pictures and their characteristics descriptions in the literature [17, 18, 19, 20] and internet services from related museums [21, 22, 23, 24]. Many apparel designers would like to use them as their ideation resources to design innovative apparels.

Main design attributes of western apparel in Renaissance era can be divided into six parts: upper clothing of male, lower clothing of male, profile of male, upper clothing of female, lower clothing of female and profile of female. Sub-attributes of upper clothing of male can be further divided into shirt, doublet, jerkin, slash, zimarre and ruff. Sub-attributes of lower clothing of male can be divided into cannions, socks and lower skirt or trout. Sub-attributes of upper clothing of female can be further divided into headdress, neckline, corset and sleeves. Sub-attributes of lower clothing of female can be further divided into mantle, skirt, farthingale and chopine. The alternative options of corresponding shape varieties include Italian style, Germany style, English style and Spanish style emerged in Renaissance era..

We use upper clothing of male as an example. The followings show how to establish morphological matrix charts step by step:

Step 1

Independent design attributes include shirt, doublet, jerkin, slash, zimarre and ruff, and put them on the horizontal axis. Items on the vertical axis are all options of each design attribute. Table 10 shows the finished morphological matrix chart with all design solutions in picture state.

Table 10 Morphological matrix chart with all design solutions in picture state（Apparel in Renaissance era）

Step 2

Use the same process as step 1, but design solutions are in profile state. Table 11 shows the finished morphological matrix chart.

Table 11 Morphological matrix chart with all design solutions in profile state（Apparel in Renaissance era）

Attribute / Styles	A. Shirt	B. Doublet	C. Jerkin	D. Slash	E. Zimarre	F. Ruff
Option 1						
Option 2						
Option 3						
Option 4						

Step 3

European national apparel styles include Italian style, Germany style, English style and Spanish style and put them on the vertical axis. Table 12 shows the finished morphological matrix chart.

Table 12 Morphological matrix chart with all design solutions in picture state（Various national style apparel in Renaissance era）

Attribute / Styles	A. Shirt	B. Doublet	C. Jerkin	D. Slash	E. Zimarre	F. Ruff
Italian 1				none		
Germany 2						
Spanish 3						
English 4						

Step 4

Use the same process as step 3, but design solutions are in profile state. Table 13 shows the finished morphological matrix chart.

Table 13 Morphological matrix chart with all design solutions in profile state（Various national style Apparel in Renaissance era）

Attribute / Styles	A. Shirt	B. Doublet	C. Jerkin	D. Slash	E. Zimarre	F. Ruff
Italian 1				none		none
Germany 2						none
Spanish 3	none	none		none	none	
English 4	none	none		none	none	none

Step 5

Use the same process as step 4, but design solutions are the characteristics descriptions of each apparel profile. Table 14 shows the finished morphological matrix chart.

Table 14 Morphological matrix chart for apparel in Renaissance era（design solutions are Characteristics descriptions）

Attributes / Styles	A shirt,	B doublet,	C jerkin	D slash,	E zimarre	F ruff
Italian	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt	none	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt	none
Germany	1. upper clothing still mainly dress doublet 2. source the inner shirt 3. appear overlap at wrist and neck part	1. upper clothing still mainly dress doublet 2. source the inner shirt 3. appear overlap at wrist and neck part	1. upper clothing still mainly dress doublet 2. source the inner shirt 3. appear overlap at wrist and neck part	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt	1. upper clothing still mainly dress doublet 2. source the inner shirt 3. appear overlap at wrist and neck part	none
Spanish	none	none	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt	none	none	1. sleeve very large 2. mostly made of rill 3. if Dress the doublet the neck part will appear part shirt
English	none	none	1. upper clothing still mainly dress doublet 2. source the inner shirt 3. appear overlap at wrist and neck part	none	none	none

Step 6

Use the morphological matrix charts established from Step 1 to Step 5 to aid apparel design or to search western apparel in Renaissance era.

(1) Morphological matrix charts aiding apparel design

Table 15 shows one particular apparel designer chooses a set of design solutions （A1+B2+C4+D0+E3+F0, or (1,2,4,0,3,0)）. That means he/she decide to use shirt（option 1）, doublet（option 2）, jerkin（option 4）and zimarre （option 3）of apparel in renaissance era to design new apparel. There are totally 2399 (3×4×5×2×4×5 −1＝2399) choices to aid the apparel designer. Table 16 shows another apparel designer chooses another set of design solutions （A0+B2+C4+D0+E1+F3, or (0,2,4,0,1,3)）. That means he/she decide to use doublet（Germany style）, jerkin（English style）, zimarre（Italian style） and ruff（Spanish style） of apparel in renaissance era to help designing new

apparel. There are totally 539 (3×3×5×2×3×2−1＝ 539) choices to aid the apparel designer.

Table 15 One application of using Morphological matrix chart（the designer chooses one set of design solutions（1,2,4,0,3,0）)

Design Decision
（**1,2,4,0,3,0**）

Table 16 Another application of using Morphological matrix chart（the designer chooses a set of design solutions（0,2,4,0,1,3）)

Design Decision
（**0,2,4,0,1,3**）

(2) Morphological matrix charts to search apparel in Renaissance era

Applying the morphological matrix charts established from step 1 to step 5, if we input desired searching conditions, we can obtain the apparel solution in Renaissance era. For example：

Input conditions：Shirt picture in Germany style with characteristics description

Output result（Ψ）：The apparel solution as shown in Table 17.
Ψ = A2；or denoted as（2,0,0,0,0,0）

Table 17 One application example of Morphological matrix charts (combine two charts, Ψ is the searching solution)

Attributes \ Styles	A shirt,	B doublet,	C jerkin	D slash,	E zimarre	F ruff
Italian				none		none
Germany						none
Spanish	none	none		none	none	
English	none	none		none	none	none

Searching Solution (2,0,0,0,0,0)

Attributes \ Styles	A shirt,	B doublet,	C jerkin	D slash,	E zimarre	F ruff
Italian	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet the neck part will appear part shirt	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet, the neck part will appear part shirt	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet, the neck part will appear part shirt	none	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet the neck part will appear part shirt	none
Germany	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet the neck part will appear part shirt	1. upper clothing still mainly dress doublet 2. cover the inner shirt 3. appear overlap at wrist and neck part	1. upper clothing still mainly dress doublet 2. cover the inner shirt 3. appear overlap at wrist and neck part	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet, the neck part will appear part shirt	1. upper clothing still mainly dress doublet 2. cover the inner shirt 3. appear overlap at wrist and neck part	none
Spanish	none	none	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet, the neck part will appear part shirt	none	none	1. sleeve very large 2. made thy made of frill 3. if Draw the doublet the neck part will appear part shirt
English	none	none	1. upper clothing still mainly dress doublet 2. cover the inner shirt 3. appear overlap at wrist and neck part	none	none	none

3. Conclusion and Future Study

From this research article we can find that every steps in the general theory of morphological analysis applied to western apparel is very trivial and delicate. But triviality and delicacy are the requisite for accurate computer inputs and process programming. The case of western apparel in Renaissance era has proved that applying morphological analysis is suitable for augmenting much more design ideas than using other traditional creation methods, such as brainstorming and synectics.

Western apparel in Baroque era or Rococo era can also apply this theory proposed by us. That means we can adopt the same six-step procedures except changing the national styles on the vertical axis and design attributes on the horizontal axis to implement morphological analysis.

The morphological matrix charts obtained in this research can be further applied to build up a matrix-type Management Information System, MIS [25, 26]. This MIS can provide future designers to efficiently use computers and internet services to search for the western apparels in Renaissance era for the source of design ideation needs.

The morphological matrix charts can also be applied to build up Decision Support System, DSS [27, 28, 29, 30], which can provide future apparel designers to effectively use computers and internet services to make good design decisions.

In conclusion, the theory proposed in this research is just a starting point but it is essential and further computer applications of morphological analysis in apparel design may be full of challenge but worthwhile for the future study.

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