Innovative Knitwear Design utilising Seamless and Unconventional Construction

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ABSTRACT

Knitting technology has made great advances in recent years, yet there is a gap between the capabilities of the technology and much of the current commercial output, which does not yet harness this potential in terms of innovative design, due to a technology gap in which research, training and investment play a significant part. At the same time innovative design is being undertaken by a number of creative fashion designers and other practitioners which takes an unconventional approach to three-dimensional design, and who are discovering the design potential of knitted fabric and knitwear. Knitted fabrics lend themselves to twisted, interlooped or draped effects, giving exciting possibilities not available to most woven or non-woven fabric constructions. Fabric and garments can be created in the round and simultaneously shaped to fit. Knitwear is suited to small scale production and therefore experimentation is possible which then influences the larger industry.

The paper presents a brief survey of current practices by innovative designers (large and small), who take a radical approach to garment design, and exploit both the two and three-dimensional characteristics of knitted construction, or its inherent flexibility and stretch-to-fit properties, using both old and new technologies.

Various approaches can be demonstrated: the fashion designer looks first at shape and silhouette, and often drapes fabric to achieve creative results: knitwear designers tend to think first of fabric in two dimensions, then apply classic shapes. Traditional pattern cutting can be simplified, allowing for drape, stretch and fabric distortion to achieve fit and wearability, with and without elastomeric fibres. Unconventional two-dimensional shapes can produce interesting results in three dimensions. Examples of innovative work from knitwear, fashion and textiles designers and artists point the way towards a more radical approach which could result in both greater diversity and mass customisation.

Keywords: Knitwear, technology, design, fashion, unconventional, three-dimensional
1. Introduction

Knitwear is an industry running parallel with, but not generally considered part of mainstream fashion. Fashion designers have not always understood knitwear, its technology is complex and specialised. Knitwear designers are usually textile trained rather than fashion, and therefore have a more two-dimensional fabric focus. The attention to three-dimensional design has not been paramount and has not sought to challenge accepted methods of garment design within knitwear. However, innovative design is being undertaken by a number of creative and avant-garde fashion designers and other practitioners which takes an unconventional approach to three-dimensional design, and who are discovering and extending the design potential of knitted fabric and knitwear, ironically, often utilising the simplest manual technology and basic fabric structures. This paper presents a brief survey of current practices by several innovative designers (large and small), who take a radical approach to garment design, and exploit both the two and three-dimensional characteristics of knitted construction, or its inherent flexibility and stretch-to-fit properties, using both old and new technologies.

2. Technological Progress in Knitting

Knitting, like weaving, has developed from a hand craft using basic tools to mechanisation of an increasingly sophisticated kind. The development of the knitting frame by William Lee in the late 16th century was a technology far in advance of its time, preceding the industrial revolution by a hundred and fifty years. Its acceptance and patronage were problematic, and Lee never saw the eventual success of his invention, which underwent much refinement before production was viable, a generation after his death. The early knitting machinery was invented to replicate hand made items such as stockings and berets which had been knitted integrally with few or no seams. With mechanisation, seamless construction was forsaken for the speed of production of shaped or 'fashioned' machine knitted fabric requiring seaming. Following the development of flat V bed and circular machines during the nineteenth century, circular seamless knitting could be produced mechanically, but output focused on fabric lengths rather than garment-sized production. The two opposite technologies of cut-and sew and fully fashioned production developed: wider machines enabled the knitting of body sized garment lengths, and fully cut garments were made from circular fabric; the addition of automated fashioning to multi-head straight bar machines stimulated the slower, but higher quality, production of fully shaped garments. 

Specialist machinery designed to produced specific items of seamless clothing evolved over the same period - the small diameter hand operated Griswold sock machine of 1878 required the manual shaping of heel and toe pouches, whereas the first fully automated machine for the manufacture of seamless gloves was introduced by Shima Seiki as recently as 1965.

From the humble beret and stockings to vests and whole body coverings, knitwear gradually transmuted from underwear to outerwear in tandem with the developing technologies of flat and circular weft knitting. Patterning systems were the next focus of development, utilising mechanical needle selection in adaptation of the jacquard weaving system. In the post-war years, knitting machine industries built up around the world, in particular in Germany, Italy and Japan, with Germany becoming dominant in the warp-knitting industry. Circular weft knitting gained in prominence in the early twentieth century with the invention of double cylinder machines. Double jersey fabrics were manufactured by cut and sew methods, following
established procedures used in the construction of woven garments, and for a time were the height of fashion in new synthetic yarns. The transition from mechanically-controlled machines to electronic control was the defining development of the modern knitting industry. By the 1970s most double jersey machines incorporated electronic patterning systems, linked with a computer interface design unit. In 1975, electronic control was first applied to flat knitting machines, enabling individual needle selection which gave immense scope and opened up the design potential beyond the mimicking of hand-knitting. As the machine technology developed, from the invention of the presser foot to advanced jacquard variations and multiple stitch structure capabilities, commercially knitted fabrics could be created with a textured hand knitted quality and greater consumer appeal. However, garment design was a secondary factor, particularly in the UK industry. Speed and ease of production became paramount and designs either remained classic or design ideas were simplified according to mass production values.

3. Fashion in Knitwear

By the 1980s, the hand knitted ‘designer’ sweater - usually multicoloured, intricately textured and graphically patterned - had become highly fashionable in many countries. The demand thus created was influential to the development of more complex machinery to enable commercial versions of this knitwear to enter the mass market. Enhanced three-dimensional stitch structures, such as cables and blackberry stitch effects utilising held loops, were interpreted through a wider range of yarn qualities (for example acrylic chenille became ubiquitous in the 1980s) and improved computer-aided design facilities linked directly to the machinery. Australian company Coogi capitalised on the ability of the new electronically controlled machines with CAD facilities to create multi-patterned, multi-coloured knitwear designed to test the limits of feasibility and inventiveness, previously only possible by manual methods. The resulting garments were expensive due to high knitting times - hours rather than minutes- and remained at the top end of the market, with samples in the collection of the Cooper Hewitt Museum in America.

Although great attention was paid to fabric design, garment shapes for knitwear were at this time fairly standard. The sweater usually had rectangular shaped back and front with either set-in sleeves, or drop shoulder and no sleeve head shaping, with standard round or V necklines and ribbed trims. Although proportions were occasionally slightly varied, other fundamental possibilities for construction were not explored, and the consumer eventually became bored with the similar offerings of the commercial industry. Some changes have been apparent over the last 10 years - the look of knitwear has been modernised by the move towards trimless garments i.e. knitted without additional ribbed edging to stabilise the main fabric. Garments made of ribbed fabrics which are intrinsically stable have been simplified to their fully fashioned basic shape, resulting in a cleaner look. The 'doughnut' neckline and the naturally curling edges of single jersey, fortuitously simpler to produce, ceased to look so unfinished and gained popularity as a consumer offer, as deconstructed fashion has become more accepted. The improvements in technology have quietly filtered through to commercial production in the increasing use of internal wale shaping to create integral darts, and body contouring in ribbed sweaters. Classic knitwear produced by companies such as Pringle and Ballantyne has been subtly re-shaped, featuring more items with shaped side seams for closer fit, and also including trimless sweaters.
4. Integral Garment design

Integral garment knitting by industrial machine developed very slowly. A small number of alternative garment shapes were tried out by technologists in previous decades, spurred by the development of the new panty-hose, but early attempts at integral knitting of outerwear were limited and stagnated for a period from the 1960s following a Courtaulds patent which remained unexploited. However, in the last 10 years the integral concept has successfully been revived and dual technologies have been invented by the machine builders Stoll (Knit and Wear) and Shima Seiki (Wholegarment) to ultimately achieve the same goal of completely seamless outerwear garments. These machines have capabilities for advanced shaping and integral trims, fancy stitch edgings, collars and pockets to be knitted into the fabric. The satisfactory 'casting off' or 'binding off' of stitches at the finish of a garment has now been achieved - essential for the garment to be completed on the machine without further trims.

Although knitting technology has made tremendous advances in the manipulation of two and three- dimensional shape and the ability to knit entire garments on the machines, there is a gap between the capabilities of the technology and much of the current commercial output, which does not yet harness this potential in terms of innovative design. This is due to a technological knowledge gap in which the need for research, lack of training and lack of investment in new machinery has played a significant part, not only in the UK but within the Italian, Japanese and other markets. Designers and technologists need to move closer together, in order to find greater mutual understanding and communication. Design has often led the technological developments, but now with highly complex integral knitting technology, it is falling behind, as designers are unable to exploit its full potential due to a technological barrier. New paradigms for knitwear design have to be acknowledged, accepted and acted upon and the three-dimensional aspects of design must be addressed to respond to the new seamless and integral initiatives in technological possibilities. Perhaps a fashion-based alternative view can be helpful in moving the industry forward.

Knitwear design is a hybrid activity, falling uneasily between fashion and textiles, yet this position creates wonderful opportunities. Knowledge of technical knit construction is essential in order to create new and innovative knitted fabrics and garments. Various approaches can be demonstrated: the fashion designer looks first at shape and silhouette, and often drapes fabric to achieve creative results, or uses the simpler fabrics such as ribs and cables to enhance proportions; knitwear designers tend to think first of fabric development in two dimensions, then apply classic shapes. Within knitwear design, traditional pattern cutting can be simplified, allowing for drape, stretch and fabric distortion to achieve fit and wearability, with and without the use of elastomeric fibres. Taking this idea further, unconventional two-dimensional shapes can produce interesting results in three dimensions. Examples of innovative work from knitwear, fashion and textiles designers and artists point the way towards a more radical approach which could result in both greater diversity and mass customisation as the flexibility and sophistication of modern programming continues to improve.

The key characteristics of knitted fabrics - flexibility, drape, stretch and recovery- can be

enhanced (or sometimes denied) according to the infinite number of possible combinations of variables: yarn choice, stitch density, machine gauge, fabric structure and fabric finishing. (This amalgam of structure, yarn choice, gauges and finish is of course what keeps all constructed textile design alive and well!) Uniquely in knitting, fabric and garments can be created in the round and simultaneously shaped to fit. The fundamental weft knitted structure is familiar from hand and machine knitting in the domestic sphere and the simplest construction of stocking stitch or plain fabric forms a major component of much knitwear: fine gauge classic sweaters and cardigans industrially produced in wool and cashmere, or coarse gauge casual knitwear made both by manual and industrial production, comprise an important element of a staple wardrobe wherever the weather requires warmth. But knitwear is a great deal more than the classics. Although contrary to the historically separate evolution of the hosiery and knitwear elements of the industry, it can be useful to consider the full spectrum of gauges as a continuum: from chunky hand knitting to jersey fabrics which are taken for granted in underwear and T-shirtng, and the finest knit constructions of hosiery. As the fundamental constructions of weft knitting are identical at any gauge, technology transfer has started to merge separate aspects of the knitting industry, for example hosiery and outerwear. Contemporary knitwear therefore should not be identified solely with the classics, nor the medium gauge textured and jacquard patterned acrylic sweaters favoured in the commercial knitwear of the 1970s and '80s. Jersey and fine gauge fabrics in viscose, silk or synthetics can impart fluidity and drape for glamorous evening wear, or for total knit dressing, wools and luxury fibres are chosen by designers such as Nicole Farhi, Sonia Rykiel and Joaquim Verdu who dress working women for comfort and practicality with sophistication. The incorporation of elastomeric yarns into jersey fabric has given a completely new dimension to knit construction, as patented initially by Rosemary Moore in 1985 with her groundbreaking Maxxam ruched jersey fabric. The uses of knit construction are diversifying, demonstrating its versatility. Knitted fabrication now crosses into many disciplines including product and interior design, automotive and office seating, and medical or industrial textiles.

5. The influence of craft knitting

Many of the influential British knitwear designers of the 1980s relied on hand or domestic cottage industry production. Knitwear is suited to small scale production (in the same way as the original framework knitters operated on an individual self-employed basis) and therefore experimentation is possible: the key design ideas are still created by individual knitted textile designers (either freelance or within design studios) usually working on domestic and hand flat machines, as can easily be witnessed every 6 months at the European textile trade fairs such as Indigo and Pitti Filati. These inventive fabric ideas then influence the wider fashion industry, via interpretation by fashion designers and knitwear manufacturers. Despite the advances in industrial technologies, the craft approach is still a seedbed of ideas which fuels the commercial industry. Textile and fashion students contribute fresh ideas to companies whilst on work experience, and are often an essential element within the design cycle. A newer development has seen design swatches sold as miniature half garment ideas, a concept which has given knitted textile designers with a flair for styling the ability to suggest a fashion mood. These are the designers who most need to access the latest technology, but are prevented from doing so by a technological and financial barrier. A small number of well established design studios, mainly in Italy, have invested in compact industrial machinery, but still utilise a range of manual machinery
to attain diversity and a wide range of fabric qualities.

6. Unconventional Fashion Knitwear

During the 1990s, fashion has become more sophisticated, and the consumer more design aware. As global electronic communication has become the norm, leading edge designers exert powerful design influence, in an industry hungry for new ideas. So-called ‘intellectual’ collections, for example Hussein Chalayan and Martin Margiela, which demonstrate a clear and creative thought process are influential now at all levels of the fashion industry. This can be exemplified by the fact that deconstructed, frayed, raw edges were initially only seen in high fashion avant-garde collections, but now have swept through all levels of the market to the high street. Many fashion designers, such as Gaultier, Westwood, Margiela and Chalayan, incorporate in their collections a range of knitwear which may or may not be shown on the catwalk. Margiela works each season with classic knitwear, but subverts expectation in some way - garments may be treated with surface effects, oversized and moulded to shape, or left unfinished like the classic merino button-through cardigan which has no neckline cut out. He also experiments with the way knitwear is constructed, always challenging our preconceptions: sleeves are turned inside out through an opened armhole; for winter 2002, double layer sweaters and cardigans are made from standard front and back pieces folded back on themselves creating unusual but wearable necklines. Chalayan changes the scale, or the way the garment covers the body, to create difference and has shown jersey dresses with enclosed arms and gloved hands, enlarged armholes which reveal the body, or dresses with fabric extensions held in front. Jean-Paul Gaultier regularly uses hand knitted Aran pieces from sweaters with subtle style variations to couture hand knitted masterpieces. He also works regularly with patterned jersey fabrics layered under or over woven fabrics, or medium gauge plain knitwear to offset dramatic accessories and outfits.

The cosy familiarity of hand knitting and coarse gauge knitwear is used regularly within mainstream and high fashion, gracing both the international catwalks and the high street stores from time to time, as knitwear’s popularity cycles through fashion seasons. Recent high fashion collections illustrate the point. Autumn winter 2001 was an important season for homespun knitted looks, in keeping with the re-invented bohemianism which has prevailed. Winter 2002 is set to be an even greater success for knitwear, with high profile knitted collections from Comme des Garcons and Yohji Yamamoto, and large-scale chunky handknits from Stella McCartney, Helmut Lang, Dior and Dries Van Noten for example. The cable motif recurs frequently and has become an iconic reference to the essence of knitwear. The technique has been exploited widely (thanks initially to the presser foot technology referred to earlier, or to cheap manual labour in certain countries) and the knitted cable is so recognisable that its simulated image can be used in printed and embroidered garments which have no yarn involved at all - as shown by Miyake’s printed. images of Aran-style knitwear on Pleats Please outfits, or of Westwood’s embroidered menswear for summer 2002.

The flexibility of knitted fabrics lend themselves to twisted, interlooped or draped effects, giving exciting possibilities not available to most woven or non-woven fabric constructions. The fluidity of draped silk or viscose jersey evening wear was typical of early Hollywood and celebrity glamour designs, often taking inspiration from classical antiquity, statuary and paintings, to
reveal the perfection beneath the fabric. The stretch characteristics of knitted fabrics, enhanced by the inclusion of Lycra, are supremely demonstrated in the body-conscious couture creations of Azzedine Alaïa, who works directly on the female body, and sculpts and moulds knitted fabrics with precise seaming and fashioning to accentuate the body contours in second skin outfits.

In contrast however, the triumvirate of influential Japanese designers Yohji Yamamoto, Issey Miyake and Rei Kawakubo have consistently demonstrated how Western notions of pattern construction and fit close to the body can be revised. Their radical approaches to clothing the body with unconventional shapes and distorted silhouettes, and wrapping, folding and manipulating fabric in many new ways around the body initially shocked the fashion world, but have over the last 25 years become highly influential in transforming attitudes. The clothes, although built upon the principles of Japanese kimono dressing, were just as uncompromising and radical in their own country, but found a niche in the international fashion market, and in particular the milieu of Paris fashion. Yamamoto, Miyake and Kawakubo therefore represent not a Japanese aesthetic, but one which is intensely personal and above all continues to question the basis on which we cover the body, combining eastern and western sensibilities. In doing so they challenge all aspects of conventional thinking regarding pattern cutting, and work both with the body and against it, utilising the innovative concept of the space between the body and clothing to articulate an individual vision. When they turn their medium of expression to knitwear, this follows one of two paths: the first applies a three-dimensional understanding of design to the flexible and reversible aspects of knitwear, exploiting knitting for its specific qualities; the second utilises the visual, tactile and stretch malleability of knitted fabric to achieve a radical vision.

Examples of the first approach can be seen in Yohji Yamamoto’s work. He has consistently demonstrated an unconventional attitude to the construction of knitted garments - especially their shape in two dimensions. Drape, twist and reversibility are all utilised in the design of his knitwear which often forms a leading feature of the collections. They illustrate unconventional three-dimensional results on the body created from two-dimensions, often one piece of fabric with a Moebius-like twist. Yamamoto's most innovative twisted and wrapped structures use the simplest single jersey domestic knitting machine production, but the conception of shape around the body is highly sophisticated. For example, for autumn 2001, a shoulder bag was incorporated into a knitted cardigan, which could be worn over the shoulder, through a process of turning inside out and over the body. In the winter 2002 collection, heavy gauge wraps were created from ribbed or textured knitted lengths which swaddle the body, as half scarf, half garment. Variations include a sleeve at one or both ends, or a polo neck at one end, and a skirt at the other, with one-sleeved sweaters worn underneath to complete the look.

In contrast, Rei Kawakubo of Comme des Garçons, often works around the body directly with fabric. She utilises the stretch and malleability of knitted fabric to twist around the body, working directly in three dimensions before cutting patterns. The winter 2002 collection was called 'Free Knitting' and uses 50 different knitted fabrics from coarse to fine gauges. The distortion possible with knitted fabric enable her to completely twist the pattern pieces for her garments into new three-dimensional configurations with seams displaced from their usual positions. Knitted cardigans and sweaters form a important part of the complementary ranges of Kawakubo's lines, such as Robe de Chambre, and Homme Plus. Pieces of diverse garments are re-assembled into
a patchwork of effects, or intricate intarsia and three-dimensional textures are combined in new ways. For 2002 knitwear included cardigans with a full circle back created by short row knitting.

Folding is another aspect of design imbued in the Japanese tradition of origami, and utilised to great affect by Atsuro Tayama, who once worked for Yohji Yamamoto, conceives garments which use knitted and shaped lengths to enfold and wrap the body, or layers which connect ingeniously, creating secret aspects of a garment that only the wearer is aware of. Tayama, in common with other Japanese designers, also manipulates fine knitted jersey fabrics in twisted and knotted formations, which gently bind the body. These examples of unconventional approaches to the construction of clothing and knitwear point to new ways of thinking about design in three dimensions.

7. Seamless and three-dimensional construction in knitwear

Seamless constructions presently on the market has developed from the hosiery tradition, led through the creation of body sized circular machinery adapted from the small diameter hosiery machines (such as those produced by Santoni). Current commercial seamless wear is to be found in the underwear and swimwear ranges of companies such as Marks and Spencer, Benetton and Wolford, the latter crossing into designer level with lingerie and bodywear designed by Jean-Paul Gaultier and Philippe Starck. As the approach to seamless knitwear is derived from hosiery, the use of elastomeric and nylon yarns, and close fit to the body is the overriding aesthetic (which confines the market to the younger, more body confident consumer). The seamless garments produced on the outerwear machines of Stoll and Shima Seiki using their innovative technology has so far tended to mimic what can currently be done by conventional flat knitting methods. Now that the machinery has proved its quality, radical thinking and new approaches to garment construction could lead to new ways of making knitwear.

Hand knitwear designer Delphine Wilson creates knitwear which follows the three-dimensional contours of the body and is constructed from panels which subdivide, twist and rejoin so the back, front and sides merge into one. These ideas use the form of the body to create shape and inspire design, and could be translated into the new machine technology. Caterina Radvan takes a different perspective and develops seamless knitwear which includes the element of drape created through highly unconventional garment constructions. The bizarre two-dimensional shapes utilise the drape characteristics of linen and natural fibre yarns in medium gauge knitwear which, when worn, create a soft silhouette away from the body. Radvan’s unconventional approach takes different parts of the garment as starting points (for example the cuff), often utilising the idea of folding the knitted fabric back on itself, which enables the garment to be worn in several ways.

Testu, a new French label, recently utilised seamless tubular knitting to create distorted two-dimensional garment shapes which bend to one side due to extra knitted fabric, which gave asymmetrical draped effects, and were designed to be unisex garments. Further ideas come from a British design duo, Alice Lee, who have recently shown a new way of constructing dresses, using short row knitting techniques on manual machines with fluid viscose yarns. Each dress is made from one main piece with minimal seaming, and is constructed in a circular formation from a focal point in the centre of the dress, creating striking visual qualities which enhance the
geometry of the construction. A number of international fashion designers have started to used seamless knitwear, notably Lawrence Steele, whose sophisticated collections often incorporate experimental fabrics. He capitalises on the tubular basis of seamless knitwear in body skimming dresses and sweaters knitted without sleeve seams and internally shaped fitted yoke or fitted waistlines featuring intricately knitted darts.

Direct three-dimensional construction is possible in both weft and warp knitting, but this is mostly exploited in technical applications at present, and there is immense potential for technical crossover to clothing and fashion applications, clearly requiring imaginative research to progress the ideas. Warp knitted constructions are beginning to be used increasingly in fashion in addition to traditional warp-knitted products of furnishing fabrics, knitted laces, fishnet tights and mesh packaging. Missoni initiated this movement to fashion in the 1950s with their signature colourful zig-zag stripes, by adapting warp knitted fabrics from shawls to creating knitwear. Since 1999, warp knitting has been taken up spectacularly by Issey Miyake in his APOC collections to produce the ground-breaking and still highly experimental one-piece tubular jacquard mesh designs. The APOC (One Piece Of Cloth) collection now forms the focus of Miyake’s current endeavours, having handed over his main line collection to his protégé Naoki Takizawa in order to focus on APOC together with Dai Fujiwara. The project is an ongoing experiment in which the consumer participates, by selecting the variations in style available within the garments laid out in the roll of fabric which comes off the machine, requiring no finishing processes at all. The fabric is a mix of either cotton or wool with nylon and polyurethane, with a high level of stretch. There is no wastage, no sewing or after knitting processes are needed, making the concept true to the ideal of one piece of cloth (as in the traditional kimono). The experiment has developed season by season, from the conceptual basis of total living in which items of furnishing such as cushions and pillows were incorporated, to a concentration on the younger fashion-conscious and avant-garde clientele who have responded to the APOC concept. This radical and uncompromising idea demonstrates how a new paradigm for clothing can be created and that knitting technology has been the means to develop it. The APOC concept has now been translated to woven garments, in contrast to the usual movement of technologies from weave to knit, although sewn seams are sometimes used.

Knitted construction offers phenomenal diversity and range of potential end products. Technological advances in knitting have at present outstripped the market's ability to absorb and utilise it. A greater understanding (and perhaps more merging of roles) between technologists and designers is now required to create a dialogue from which design innovation can spring. Much more experimental design research is essential to open new approaches to explorations which will result in new approaches to knitwear and new dimensions to our clothing. As artists discover the contradictions inherent in many traditional forms and explore the boundaries of clothing and art, and as radical fashion designers offer new alternatives, so the knitting of three-dimensional clothing can move to the next level, but only if experimentation and creative risk-taking can be fostered.

**Bibliography**