

Creators and makers

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We are used to thinking that shoes are made of leather, synthetics and many other materials that we can touch and see when we look at them in a shop or wear them on our feet. We also acknowledge that to make them nice and attractive, intelligence and skilled labour are needed, with both tangible and intangible contributions being necessary to craft the product we love. We must now become aware that today's shoes are made of 'bits', no less important than the other elements mentioned.

The digitalisation of the shoe world is a process that started more than two decades ago with the first appearance of computers, computer aided design software programs and numerically controlled machines at shop floor level. It was an evolution that was common to all the main manufacturing sectors although the footwear industry was relatively slow in absorbing the transformations that were already affecting others. Nevertheless this 'digital divide' reduced over time and shoemaking today is as digital as many other similar processes in the manufacture of different consumer goods.

Computers were used initially in the footwear industry, as in many others, to 'crunch numbers' and elaborate rapidly and precisely all the data that accounting, administration and production planning departments had to deal with. At that time graphic systems did not exist, screens of the cathode ray tube type only displayed numbers and letters and the computing power of the most powerful machines would not have matched that of an entry level mobile phone of today. Then computer graphics and computational geometry made possible the transformation of shoe designers' sketches and the lines they drew on paper into elaborated 2D projects and highly realistic 3D digital mock ups of the shoes to be produced. Bits and bytes entered design departments and creative studios revolutionising work methods, design tools and the mind-set of shoe designers.

BITS

Bits in the design meant bits were also available for the manufacturing process. A new breed of machines appeared that took full advantage of the digital revolution to manage cutting operations. At first they continued to use traditional knives and then totally eliminated these in NC controlled die-less cutting machines. Lasting operations and other more or less

complex manufacturing steps followed. Manufacturing became less hardware and more software, forcing companies to modernise their approach and to upgrade the skills of their workforce.

This so called 'soft' invasion is now unstoppable. The Internet has propelled shoe companies and their products into the immaterial world of the web where real shops have been replaced by virtual ones, retailers have become e-tailers



Soccer boot with sintered outsole.

CREDIT: NIKE

and consumers play a role few could have imagined only a few years ago. Social media has done the rest and given consumers in the digital world a power that was unimaginable in the physical one. Bits can determine the success of a product or destroy the reputation of a company at the speed of the fastest data transfer.

According to futurist Ray Kurzweil in his book 'The singularity is near', a discontinuity in the normal speed of technical evolution is approaching that will lead to a physical restructuring of an article driven by developments in so-called 3D printing technologies that will lead to 'personal digital manufacturing'. A new generation of 'makers' stands ready to take its place in the shoe production process that has the potential to radically transform producer consumer relationships. The purpose of this article is to trace the voyage of the bits through and across the processes that transform an idea into the product we know. At the end of this journey we will be surprised by how pervasive digital technologies have become and by how big their growth potential remains.

DIGITAL DESIGN

Using graphic design software to draw the first conceptual ideas of a shoe and CAD programs to transform these into a product through steps such as 3D modelling, shell flattening, pattern engineering and grading can nowadays be considered common practice. The debate between 3D philosophers whose credo originates from the basic fact that shoes are three dimensional and should be treated as such by any design software and 2D pragmatists who would rather stick to the classical pattern engineering school remains unresolved. Nevertheless, there are no longer any doubts that digital design is more efficient, more flexible and can generate an enormous amount of information (digital data) whose utilisation goes largely beyond the boundaries of the design department.

An accurate 3D model of a shoe with a careful reproduction of all its components, the various materials it is made from, their thicknesses, textures, properties and layering can generate a highly realistic rendering of the shoe itself in the form of a 'virtual prototype'. Specialised software tools exist that are able to place it in an appropriate



Virtual mock up of a high quality man's shoe.

CREDIT: SUTORIA FOR CALZATURIFICIO PAKERSON

scenario and with an accurate reproduction of the effects of light on the various materials involved. The final result is often almost impossible to distinguish from a photograph of a real prototype. There is just one difference however: virtual prototypes are much cheaper to produce. They can also be changed much more easily, transferred from one place to another at virtually no cost and evaluated by buyers and end users long before any manufacturing commitment is taken, a marked superiority of 'bits' versus 'atoms'.

VIRTUAL REALITY

Virtual prototyping relates to virtual reality as real prototypes do to reality. In the digital (virtual) world things simply happen faster and at a lower cost. There are several other examples that we can make such as shoe configurators for instance. These are special software applications that enable consumers to configure a personalised pair of shoes by choosing from the various style, accessory, material and colour options the producer makes available when they order online or in a shop. In such a scenario there is no physical interaction between the customer and the real product until they receive the finished product and the only guide they will have in the whole purchasing process is visual; the highly realistic digital model of the shoe they have created themselves. Quasi-real rendering effects are paramount in this situation

because they can make all the difference between a purchase transaction and a missed sale.

AUGMENTED REALITY

And again, if the digital model of the shoe is so realistic, why should I not see it on my feet just as if I was really wearing them? This takes us to another realm of the digital world, augmented reality. Devices such as 'magic' or virtual mirrors can combine real, dynamic images of the consumer standing in front of a camera wearing a digital model of the as yet non-existent shoe.

Bits can also be easily tweaked. For instance, let's take the digital model of the shoe we mentioned earlier and change the focus from aesthetics to function. Instead of concentrating on accurately reproducing the texture and thickness of a material, let's see if it is possible to model its physical properties (flexibility, mechanical resistance, thermal behaviour and wear properties) and to incorporate these into the 3D model. What we obtain is a functional digital prototype that can be used to predict the shoe's behaviour, performance and interaction with the foot. This is what major producers of sports shoes such as adidas, Nike and Decathlon now do in their R&D departments at a level of sophistication rivalling that of the automotive or aerospace industries. Not bad for a so-called traditional sector and all thanks to CAD software and 3D digital models.

DIGITAL PROCESSES

Bits migrate from the design to the manufacturing processes. Pattern contours from 2D CAD or trajectories of various kinds extracted from 3D digital models, feed and control a wide range of machines from the obvious die-less cutting tables to NC stitching stations, programmable lasting machines, roughing and cementing systems through to robots executing a variety of tasks. A continuous stream of data flows from design to manufacturing. Data in fact exists all over the manufacturing plant in the exchange of status and operational information between machines and manufacturing execution systems (MES) as well as identification of data stored in components and finished shoes. It is all forwarded to centralised supervision systems through RFID (radio frequency identification) devices reading the tag that contains the data. Production is more and more immersed in a cloud of bits that ensure its smooth and controlled functioning, clouds that cannot be seen but are vital for the daily activity of the factory.



Shoe produced on a 3D printer. CREDIT: MATERIALISE BELGIUM

CREATORS AND MAKERS

Something even more disruptive is now knocking at the door; 3D printing and direct digital manufacturing. We are now all familiar with the usual definition of rapid prototyping (RP), i.e. with the range of technologies and systems that are capable of transforming a digital model of an

object (a component of the shoe for example) into its physical form with a few direct and simple steps. The very name 'rapid prototyping' machine clearly indicates their original area of application, the design and prototyping department. They remained there due to the long processing time it took in the past to create the object and for the

limited number of materials they could process. Furthermore, the fragility and rigidity of the objects they were capable of creating did not permit to them to be used for anything other than aesthetical evaluation as all functional applications were precluded.

In the last ten years or so, these technologies have undergone development to bring them to a much higher level of consolidation in two major directions, the range and characteristics of the materials they can process and the reduction of the investment needed to purchase and operate them. There has also been a progressive streamlining of manufacturing techniques. What all these systems have in common though is that the final object is obtained by solidifying (adding material) with different physical or chemical processes layer after layer and bonding them all together rather than chipping off material from a block of plastic or metal using appropriate cutters (subtractive techniques).

Among the many different approaches that have so far been tested (laminated manufacturing, stereo lithography, etc.) some have survived



Configurators allow the consumer to personalise their shoes. CREDIT: MUNICH SPAIN

and are receiving constant development attention. These include selective laser sintering (SLS), fused deposition modeling (FDM) and other simpler families of machines commonly known as 3D printers. The materials that can be processed have also evolved dramatically, both with rigid materials whose strength and durability now rivals that of many materials used in shoe making and their flexibility which allows them to be considered viable alternatives for manufacturing components such as heels, technical insoles and customised outsoles. Lasts could also be targeted but, in order to become an acceptable alternative to the traditional last manufacturing process, these advanced technologies still have one important drawback, their accruing speed (the speed at which each a layer is solidified). Although this is still relative slow compared to traditional techniques, new developments are on the verge of making it much faster.

Costs have also come down and professional systems can now be bought with an investment lower than that needed for some of the more complex shoe making machines. Simpler machines, also known as 'personal fabricators', cost no more than a high quality laser printer for paper documents. All these evolutions have pushed such machines out of the prototyping world towards full production. Their designation has also changed over time and today they are no longer referred to as 'rapid prototyping' machines but rather as 'additive' or 'direct' manufacturing ones with a clear indication of the new environment in which they will be increasingly seen in the future.

The ultimate proof of their success as emerging manufacturing technologies came at the beginning of this year when two leading sport brands (Nike and New Balance) announced the first commercial models of football boots and running shoes with laser sintered outsoles tailored to the performance of the individual athlete. If we also consider other innovative experiments that those companies have recently made in the area of alternative (digital) means of producing the whole upper (knitting it rather than cutting and assembling components) or of putting together its parts by welding instead of

stitching, we should realise that we may be on the verge of a possible manufacturing paradigm shift. It is one that takes full advantage of the abundance of digital data such as 3D models of the shoes and of digital processing technologies that can directly use such data.

This is a shift that has the potential of completely reversing the roles between shoe producers and their consumers. In a futuristic scenario we could imagine consumers looking at their clothes in the closet, deciding which kind of shoes would complete the chosen outfit, searching the Internet for a shoe design company that provides the style or

model they like most, paying for the design, downloading it into their personal 'maker-bot' and printing the shoes on the spot as we do today with a document or a photograph.

In this vision of a possible future, shoe manufacturers in fact become 'design creators' and consumers the 'makers' of the products they buy and consume, quite a genetic mutation in their respective roles and a complete rearrangement of the value chain. As so many examples have already shown us, the digital invasion is unstoppable, so it might be as well for 21st century shoe producers to be prepared for such a disruptive 'singularity point'. 



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