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ATA Engineering, Inc. Best Practices and Techniques for NX Patterning



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ATA Engineering, Inc. Innovative Solutions through Test and Analysis-Driven Design



ATA Engineering Offers Services for:

- Design
- Analysis
- Test
- Process Improvement

Outline



Motivation

Tradeoffs among different pattern generation commands in NX

Techniques for changing pattern...

- ... Spacing
- ...Position
- ...Size

Techniques for successful pattern creation on surfaces with complex topology Advanced methods for efficient creation of largescale patterns Conclusions

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Motivation



Industrial Sieves and Screens, Microfluidic Nozzles



Regular, repeating elements appear in structures in almost every industry

NX's pattern operations provide tremendous power and flexibility for easily generating such patterns However, not only are there several distinct pattern commands, there is a multitude of settings that can be used with each command

 The right understanding of these commands and their settings can help the designer create patterns as efficiently as possible, and perhaps with more flexibility than you realized!

Spacecraft Isogrid Structures



Image courtesy www.wikipedia.org

Understanding the Various Pattern Commands in NX



🧿 Pattern Feature	૨ ૪	🧿 Pattern Face		૨ ×	🔅 Pattern Geometry		૨ ×	🔅 Patter	n Curve		<u>ა</u>	X
Feature to Pattern	^	Face		^	Geometry to Pattern		^	Curve to	Pattern			^
* Select Feature (0)		* Select Face (0))		* Select Object (0)		+	* Select	Curve (0)		<u>,</u>	
Reference Point	~	Reference Point	:	×	Reference Point		V	Pattern E	efinition			^
Pattern Definition	^	Pattern Definitio	n	^	Pattern Definition		^	Layout		tinear	•	•
Layout 🏥 Line	ar 🔻	Layout	🟥 Linear	•	Layout	🏥 Linear	•	Directio	n 1		/	^
Boundary Definition	V	Boundary Defi	nition	V	Boundary Definition		V	* Selec	t Linear Obje	ect (0)	- 0 -	
Direction 1	^	Direction 1		^	Direction 1		^	Reverse	Direction		×	
* Specify Vector	× 🚛 🌆 🗕	* Specify Vecto	or 🔀 🛃 🕇	4 -	* Specify Vector	× 🛃 🕇	<i>≱</i> ▼	Spacing		Count and P	itch 🔻	
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Count 2	Comme		Descrip						ance	1	in 🔻	
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Symmetric	Pattern		Copies	entir	e features	s, can	be u	sed	irection 2			
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Use Direction 2	i cature	,			and Shap	C, 310V	vCSt					-
Pattern Increment			perform	ance	;				OK	Apply	Cancel	
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Use Spreadsheet	Pattern		Copies	obied	cts. e.a., o	curves	eda	nes.				
Orientation			00000		oto, orgr, t		, 003	<i>,</i> ,				
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Tradeoffs Between Pattern Flexibility and Efficiency





Pattern Feature offers the most flexibility, but at a price Pattern Face still offers the right capabilities for most needs Pattern curve provides the least sophistication for altering pattern spacing, size, etc.

Techniques for Changing Pattern Spacing and Position



1. List

- The space between each successive instance will cycle through a user-supplied list of spacing values (and repeat if the list is shorter than the number of instances)
- 2. Increments
 - Input an increment to be added to the spacing for each successive instance in an arithmetic progression
- 3. Spreadsheets
 - Full control over position of each and every instance
- 4. Clocking (delta and motion-based)
 - Apply an offset to one or more pattern instances

Spacing Changes - List Method



Pattern Face
Face A
✓ Select Face (1)
Pattern Definition
Layout 🔛 Linear 👻
Direction 1 ^
✓ Specify Vector
Spacing List 🔻
Count 5 🗸
Spacing Value 3 in 🔻
Spacing 1 Value = 1.000000
Spacing 2 Value = 2.000000
Spacing 3 Value = 3.000000
Direction 2 ^
Use Direction 2
🖌 Specify Vector
Spacing Count and Pitch
Count 10 👻
Pitch Distance 1 in 👻
Symmetric
Use Spreadsheet
•



Input a list of spacing values. The space between each successive instance will cycle through the list (and repeat if the list is shorter than the number of instances)

Spacing Changes – Increment Method

Patter	n Face		ა x
Face			^
🞸 Select	Face (1)		
Reference	e Point		^
🗸 Specify	/ Point	I	<u>+</u> -
Pattern D	efinition		^
Layout		Linear	•
Bounda	ry Definitio	n	~
Directio	n 1		^
🗸 Spec	ify Vector	× 4	. † _‡ -
Spacing		Count and Pit	ch 🔻
Count		5	•
Pitch Dist	ance	1	in 🔻
Symm	netric		
Directio	n 2		^
🔽 Use 🛙	irection 2		
🗸 Spec	ify Vector	× 🤳	. † _‡ -
Spacing		Count and Pit	ch 🔻
Count		10	•
Pitch Dist	ance	1	in 🔻
Symm	netric		
Pattern	Increment		^
Pattern I	ncrement		P=
Instanc	e Points		v
Use Spi	readsheet		
Orienta	tion		×
Pattern	Settings		~
Settings			×
Preview			×
		•	
		< OK >	Cancel

Pattern Increment		
-		υx
Parameters		^
Object Va	lue Expre	
- 💓 Pattern		
Direction 2: Offs 1.0	000000 p13	
Direction 1: Offs 1.0	000000 p10	
		_
Direction 1		^
Increment 0.5 in	•	
Parameter Increm	ent Mas	*
Direction 1: Offset Di 0.5	p10	×
		~
_		
•		
Direction 2		^
Parameter Increm	opt Maa	+.
Parameter Increm	ent Mas	+
		X
•		
•		
Ok	Canc	el



Input an increment to be added to the spacing for each successive instance in an arithmetic progression

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0

0

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1

1

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< OK >

Cancel

Spreadsheets provide full control over position of each and every instance



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Spacing Changes – Clocking Method

< OK >

Cancel



11

Pattern Face	৩ X		
Face	^		
🗸 Select Face (1)	Ŵ		Apply an offset to one or more
Reference Point	^		nottorn instances
🗸 Specify Point	<u>,</u> <u>,</u>		pattern instances
Pattern Definition	^		
Layout	Linear 🔻		
Boundary Definition	n v		
Direction 1	^		$ \bigcirc \bigcirc$
🗸 Specify Vector	🗙 🚛 †‡ -		
Spacing	Count and Pitch		
Count	5 👻		
Pitch Distance	1 in 🔻		
Symmetric			
Direction 2	^		
Use Direction 2			
🗸 Specify Vector	× ↑ ·	ပံ စု Clock ပဲ X Typ	
Spacing	Count and Pitch 🔻	Туре л	r Defined
Count	10 🔻	Within Pattern Definition	
Pitch Distance	1 in •	Pat	ern Points
Symmetric		Pattern Points	Select Instance Point (1)
Pattern Increment	t Y	Select Instance Point (1)	
Instance Points	^		
Select Instance Point	(0) 🕂	Clocking Delta Mot	on t ^s _x Dynamic v
		Direction 1 3 in V	Specify Orientation
Use Spreadsheet		Direction 2 0 in	Ave Handles Only
Orientation	v	•	•
Pattern Settings	×	OK Cancel	OK Cancel
Settings	V		
Preview	×	ATA Engineering trade pooret confidential and/or manifester inte	mation Any unsutherized release of this information is prohibited
	4	ATA Engineering trade secret, confidential ,and/or proprietary info	mation. Any unaution zed release of this information is prohibited.

Techniques for Changing Pattern Size and Shape



1. Increments

- Apply an arithmetically increasing or decreasing value to a shape parameter
- 2. Spreadsheets
 - •Full control over shape parameters of each and every instance

Pattern Shape Change – Increment Method

Pattern Feature		υx	ø	Pattern Increment		
eature to Pattern		^	Par	ameters		
Select Feature (1)		4	O	oject	Value	Expre
		9	Ē	💓 Pattern		
eference Point		v		Direction 1: Offs	1.000000	p11
attern Definition		^		Direction 2: Offs	1.000000	p14
ditern Dennition			Ė	Extrude(3)		
ayout	Linear	•		Start Limit	-1.000	p8
Boundary Definition	on	×		- End Limit	1.000000	p9
Direction 1		^		···· Perpendicular Di	0.500000	p4
				Radius Dimension	1 0.250000	radius
 Specify Vector 	X <u>v</u> . ļ	•		Perpendicular Di	0.250000	D6
Spacing	Count and Pitch	•		Parallel Dimensio	0.000000	slot_v
Count	5	•				
Pitch Distance	2 in	•	Die			
Symmetric			Dire	ection 1		
Direction 2		^	Incr	rement 0.1	in 🔻	Mag
Use Direction 2			Pa	rallel Dimension be	0.1	slot
 Specify Vector 	× J † 4	. •				
Spacing	Count and Pitch	•	•			
Count	10	•				
Pitch Distance	2 in	•	Dire	ection 2		
Symmetric			Pa	rameter	Increment	Mas
Pattern Incremen	t	^				
Pattern Increment		P1= P2=				Þ
Instance Points		~			•	
Use Spreadsheet					ОК	Can
Orientation		v				
Pattern Settings		~				
attern Method		^				
ethod	Variational	•				
Reusable Referen	ces	~				
review		v				

OK

Cancel



Sketch must be made internal to extrude operation – this has performance consequences

Only Pattern Feature allows for complete parameterization of underlying sketch geometry

Tip – Use Simple Hole Command for Flexible Creation of Hole Patterns





Rather than using Extrude with an internal sketch, the Simple Hole command offers an efficient means of generating patterns of non-constant size

Limited to circles



The "Simple" Method of Pattern Feature Provides Significant Performance Gains





Techniques for Effective Use of Patterns on Complex Surfaces



For generally curved surfaces, it can be challenging to create patterns that follow the surface curvature, maintain the desired shape, and avoid self-intersection

Several techniques exist to help facilitate pattern creation on surfaces with complex topology



Default Settings with Pattern Commands Can Produce Undesirable Results





Pattern Feature with Extrude causes circles to become ellipses on highly curved regions

> Pattern lines skewed relative to right edge

Pattern Feature with Simple Hole maintains circularity, but instances overlap

Use the Layout Controls to Guide Pattern Propagation in a Direction



Pattern Feature		_ર ર			
Feature to Pattern		^		•	Diai
✔ Select Feature (1)				•	Rigi
Reference Point		v			star
Pattern Definition		^			• • • •
Layout	Along	•		•	Offs
Direction 1		^		_	Tue
Path Method	Offset	-		•	Irar
✔ Select Path (1)		× ⁄ \	\		
Specify Origin Curve		>	Rig	id	
Spacing	Count and Pitd	h ▼	Off	set	
Count	10	-	Tra	nslate	e
Location	% Arc Len	gth 👻			
% Pitch By	9	•			Ri
Direction 2		^			
Use Direction 2					
Pattern Increment	t	^			
Pattern Increment		P1= P2=		$ \rightarrow $	90
Instance Points		×			
Use Spreadsheet					
Orientation		^	1		
Orientation	Same as Input	•			
Follow Face					
 Select Face (1) 					
Project Direction	Along Face Nor	rmal 🔻		•	Trar
Pattern Settings		~		-	IIai
Pattern Method		^			
Method	Simple	•			
Preview		v		\bigcirc	00
	•			\bigcirc	00
	ОК	Cancel			

- Rigid: Instance locations are calculated as rigid motion from the start location
- Offset: Input feature's location is projected along path normal
- Translate: Path is translated to instance feature reference point



Using Two Directions With "Along" Layout May Be Worse Than Repeated Patterns in a Single Direction





Isoparametric Curves and Point Sets Can Help Facilitate Rapid Creation of Repeated Patterns





Points can be used as seed locations for creation of base instance for a pattern

Follow Face Option Provides Methods for Control of Pattern Orientation



Pattern Feature	<u></u> ບ	×
Feature to Pattern		^
🖋 Select Feature (1)	4	J
Reference Point		v
Pattern Definition		^
Layout	Linear 🔹	•
Boundary Definition	on v	·
Direction 1	v	·
Direction 2	v	·
Pattern Incremen	t v	r
Instance Points	v	1
Use Spreadsheet		
Orientation	^	•
Orientation	Same as Input 🔹	
Follow Face		
🗸 Select Face (1)		
Project Direction	Along Pattern Plane Ni 🔻	
Pattern Settings	Along Pattern Plane Norma	I
Tuttern Settings	Along Vector	1
Pattern Method		^
Method	Variational	-
Reusable Referen	ces v	r -
Preview		v
	A	
	OK Cancel	

Direction – Along Pattern Plane Normal

For arbitrarily curved surfaces, Along Pattern Plane normal typically provides undesirable results

<u>Direction – Along</u> <u>Face Normal</u>



Circular shape is maintained, but now pattern lines drift into each other

NX Open Pattern Tool Created by ATA Provides Significant Performance Gains





Keys to efficiency realized by ATA tool

- History-free mode
 - The history tree provides excellent capabilities for undoing or changing parameters
 - For very large operations, can be faster to recreate from scratch in history-free mode rather than maintain feature history for retroactive alteration of parameters
- Batch mode
 - Batch mode runs a set of NX commands in a non-interactive fashion (i.e., the part file must be saved at the end of the commands and then opened to see the result)
 - Bypassing the graphics window can provide significant performance gains

10,000 Instance Pattern with Shape Transition Created by ATA Tool in 10 Hours





- Pattern consists of 10,000 shapes transitioning from circles to slots
- Generation time is ~10 hours



Carefully consider the needs of your use case to choose Pattern Feature, Pattern Face, Pattern Curve, or Pattern Geometry

• Implications for performance

Start off with the Simple Method

 Only use the Variational Method if using the Simple Method doesn't provide the right capabilities

For complex, curved surfaces, the Follow Face and Along Layout techniques can help ensure successful pattern generation

When using NX Open to automate very large operations, consider using history-free and batch mode





Questions?

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